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PRICING OF CREDIT DEFAULT SWAPS – EVIDENCE FROM THE SCANDINAVIAN AND FINNISH MARKETS

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Abstract
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PURPOSE OF THE STUDY

The purpose of the study is to concentrate on pricing of the credit default swaps with a Scandinavian or Finnish company as a reference entity. The valuation aspect of the study is divided into two sections. First, the credit default swap market premiums are explained using the corporate bond spread. Second, the CDS valuation model is used to price the credit default swaps.

In addition to the two pricing aspects, a third emphasis of the study is on the evaluation of the different risk-free term structures on pricing of the default swaps. In order to study this aspect both treasury and swap rates are used as the risk-free term structures.

DATA

The data set in this study consists of market quotes for corporate bonds, credit default swaps and default-free interest rates. The dataset is limited to the quotes of the Scandinavian and Finnish companies, which have had outstanding corporate bonds and credit default swaps since the early 2001.

RESULTS

The empirical findings of the study indicate that both the corporate bond spreads and Hull and White's (2000a) CDS valuation model premiums can effectively be used as the estimators of corresponding credit default swap markets premiums. The results suggest that on average the model premiums are less biased estimators of the corresponding default swap market quotes, whereas the marginal effect in both of the frameworks is equally close to that expected by the hypothesis.

The study also finds that the swap rates outperform the treasury rates in valuation of the credit default swaps. Compared to the treasury rates both the bonds spreads over swap rates and valuation model premiums based on swap rates give more consistent estimates of the actual market CDS premiums. The results hence verify the findings of the previous studies.

KEYWORDS

Credit derivatives, credit default swaps, risk-free term structure, valuation

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1 INTRODUCTION

Until the beginning of the 1990's the credit risk remained one of the major components in the capital markets for which no specific risk management instrument existed. After introduction at the International Swap Dealers' Association (ISDA) conference in 1992 the credit derivatives market has experienced considerable growth. In ten years the markets have developed to a significant venue for credit risk management with total market notional well over one trillion U.S. dollars. The credit derivatives instruments enable market participants effectively transfer and repackage credit risk, basically for the first time without a pure cash alternative. Ranging from credit spread options to credit link notes, a large variety of different credit derivatives are available today for different purposes of credit risk management. However, despite the existence of number of distinct credit derivative instruments, the recent surveys (e.g. BBA, 2002) have shown the one instrument, namely credit default swaps (subsequently CDS for short), to be the dominant and most important product on the credit derivatives markets.

The considerable growth in volumes of the credit derivative markets during the past few years has been driven by several factors. First of all, increasing need for banks to improve their financial performance has led financial institutions to actively manage the concentration and correlation of credit risk related to their portfolios (Bowler & Tierney, 1999a). Second, due to the capital relief allowances, credit derivative instruments also offer an effective way to manage the economic and regulatory capital required to support the operations. Also recent and often unexpected financial difficulties of several large and well-known U.S. and European companies have further given justification for the credit risks management using credit derivatives.

Due to the relatively immature credit derivatives markets, basically all academic studies concentrating on the credit derivatives, and especially on the credit default swaps, are published not until the latter part of 1990's. The research field is therefore still young and a wide array of topics remain to be studied further. For example, first papers concentrating purely on pricing of the credit default swaps were published not until year 2000, indicating space and need for further studies related to the subject.

1.1 Objectives of the Study

The purpose of the study is to concentrate on pricing of the credit default swaps with a Scandinavian or Finnish company as a reference entity. As already mentioned, only few previous studies concentrate on pricing of default swaps and most of them use purely U.S. data (e.g. Hull and White, 2000a). Hence, extending the focus on European, and more accurately on Scandinavian data, contributes to the existing research on the subject.

The valuation aspect of the study is divided into two sections. First, the credit default swap market premiums are explained using the corporate bond spread. Second, the CDS valuation model is used to price the default swaps. As the methodology for the valuation of the credit default swaps is still relatively new, the study additionally provides evidence whether the pricing models give valid estimates for the credit default market premiums. It is also examined whether the model can effectively be implemented for estimation of default swap premiums of smaller and in some cases less liquid Scandinavian CDS markets. In addition to these two pricing aspects, a third emphasis of the study is on the evaluation of the different risk-free term structures on pricing of the default swaps. As recent studies (e.g. Houweling et al., 2001) have suggested, the market may no longer see the treasury rates as the risk-free benchmark. In order to study this aspect both treasury and swap rates are used as the risk-free benchmark in the empirical part.

The thesis is organised as follows: The second chapter introduces the general credit derivative instruments and markets. In the same chapter are also discussed credit default swaps in more detail together with the economies related to credit derivatives. In chapter 3 the major credit risk model literature is presented together with studies related to pricing of credit default swaps and bond spread determinants. The hypotheses introduced in chapter 4 are followed by the introduction of methodology in chapter 5. The data is presented in chapter 6. The empirical results are reported in chapter 7 with the summary of findings in the final chapter.

2 CREDIT DERIVATIVES

The concept of credit derivatives was for the first time introduced at the annual meeting of the International Swaps and Derivatives Association (ISDA) in 1992. Although financial instruments with similar credit risk management functions have been available in different forms already before, it was not until the 1992 ISDA conference that gave credit derivatives a framework that enabled their further development and growth. At the time also the credit derivative documentation was simplified and standardized further improving the efficiency of the markets and contributing to higher volumes and liquidity. Since the introduction in the early 90's the credit derivative markets, and especially the default swaps, have experienced an impressive growth in terms of liquidity and trading volume. According to the annual Credit Derivatives Survey (Patel, 2002) the credit derivatives market size, measured with the outstanding notional, was estimated to total 1.4 billion US dollars at the end of 2001. Although the credit derivatives markets, measured in gross volume, are still fairly small, it has nevertheless been the fastest growing sector of the global derivatives markets during the past few years (Smith, 2000).

2.1 Credit Derivative Markets

The primary purpose of the credit derivative markets is to enable the efficient transfer and repackaging of credit risk (O'Kane, 2001). According to O'Kane's definition the credit risk encompasses credit related events ranging from a spread widening, through ratings downgrade all the way to the actual default, i.e. the factors that have an impact on the pricing of the underlying credit risk instrument.

According to Das (1995a), a credit risk derivative can be defined as a financial instrument, whose payoff is linked to the credit characteristics of a particular reference asset. In their basic format, credit derivatives are negotiated contracts, where the writer (protection seller) offers protection for the buyer from a fall in value of the underlying credit risk instrument. In more exotic forms credit derivatives enable the credit profile of a specific asset or group of assets to be split up and redistributed to more concentrated or diluted portfolios to meet the preferred credit risk profiles of market participants. Further, credit derivatives separate the ownership and management of credit risk from other aspects of owning a financial asset and therefore offer a pure instrument for the credit risk management. Currently most of the default swaps are privately negotiated over-the-counter instruments, although the secondary trading and liquidity of the instruments has grown rapidly during the past few years.

Compared to pure cash instruments, credit derivatives offer market participants an efficient way to transfer, concentrate, dilute and repackage credit risk synthetically. Instead of managing credit risk using cash instruments, credit derivatives can be used to replicate the similar credit risk profile. Moreover, credit derivatives in general are unfunded products, which has made possible for the first time the separation of the funding considerations from pure credit risk management. This feature has enabled the market participants with high funding costs to access the credit risk markets and made the hedging in general more inducing.

In addition to using credit derivatives for pure hedging or credit risk trading purposes, the regulatory treatment of banks' capital adequacy requirements plays a major role in credit derivatives markets. Accounting for over 50% of the total market notional, banks are by far the biggest operators in the credit derivative markets. Hence, the changes in the regulatory treatment for capital adequacy management will certainly have an effect on the dynamics of the credit derivatives markets.

Ranging from credit default swaps to credit spread options there are a vast number of outstanding instruments that can be classified as credit derivatives. Table 2.1 shows the market share at the beginning of the year 2000 for the different credit derivative products ranked according to the outstanding notional amount.

Table 2.1 Market share of Credit Derivative Products According to Outstanding Notional

Credit Derivative Instrument	**Market Share (% Notional)**
Credit Default Swaps	38%
Credit Spread Products	18%
Total Return Swaps	17%
Asset Swaps	12%
Credit Linked Notes	10%
Repackaged Notes / Hybrids	5%

Source: BBA (2000)

As from the Table 2.1 can be seen, the credit default products and especially default swaps have been dominating the credit derivatives markets. In fact, according to the British Bankers

Association's 2002 Credit Derivatives Survey, the single-name credit default swaps continued to be single most popular derivative also in the 2002 with an increased market share of 45%. Other instruments gain in popularity include portfolio products/CLOs with an expected market share of 26% by 2004 according to the same report. Instruments that captured no more than 8% market share in year 2001 are either not predicted to do so during the next few years (BBA, 2002). The characteristics of the most common credit derivative instruments illustrated in Table 2.1 are described in more detail in the following section.

2.3 Types of Credit Derivative Instruments

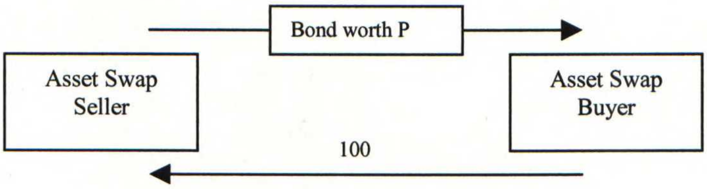
As described earlier, the focus of the study is on the pricing of the credit default swaps, which are described in more detail in the section 2.5. However, in order to gain better understanding of the structures and dynamics of the credit derivatives markets, it is useful to briefly go through the most important credit derivative and structured credit products. The instruments described in the following include asset swap, total rate of return swap, credit spread options together with the brief look at the other major credit derivative products on the market.

2.3.1 Asset Swaps

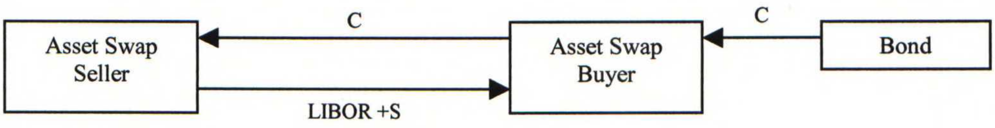
Asset swap is a specially created package, which enables the investor to buy a fixed-rate bond and then swap the fixed coupon payments to floating ones. With this transaction the investor is able to hedge out almost all of the interest rate risk that is involved in the original fixed coupon payments of the bond. While the exchange of interest payments from fixed to floating can be done using plain vanilla interest rate swaps, the asset swap structure involves also credit risk aspect. The asset swap buyer bears all the credit risk that is related to underlying bond, which is economically equivalent of buying a floating rate note issued by the same entity as the original fixed-rate bond. For this credit risk the asset swap buyer receives an excess spread known as asset swap spread. The structure of par asset swap is illustrated in Figure 2.1.

Figure 2.1 Par Asset Swap

At the initiation Asset Swap buyer purchases bond worth price P in exchange for par



A buyer enters into an interest rate swap paying a fixed coupon of C in return for Libor + spread



Source: O'Kane (2000)

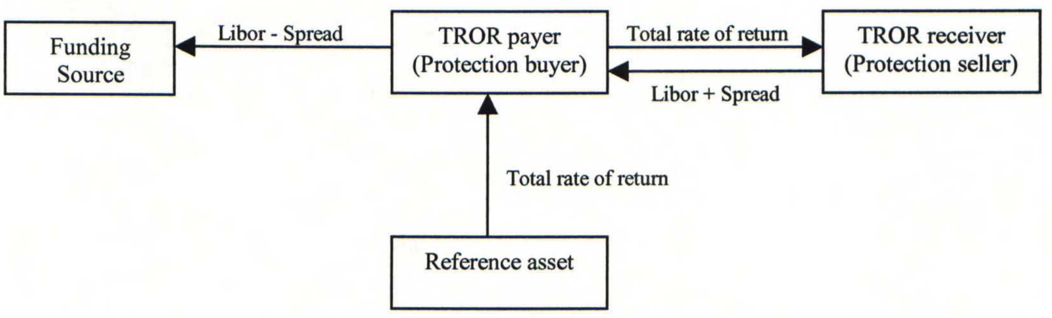
Although there are several variations of asset swap structures, the par asset swap illustrated in Figure 2.1 represents the most widely traded contract form. In the simplest form, the asset swap consists of two separate trades. First, in return for the up-front par payment the buyer receives a fixed rate bond from the asset swap seller. Second, the counterparties enter into an interest rate swap to pay fixed coupon to the asset swap seller that is equal to coupon of the bond. In return the asset swap buyer receives floating rate payment of Libor plus an agreed fixed spread. The fixed spread is usually set at a breakeven value such that the net present value of the transaction is zero at the initiation.

In the asset swap contract the buyer effectively sustains the credit risk of the bond. However, if the bond defaults, the asset swap buyer still has to continue on paying the fixed side coupon that can be no longer funded with the coupons from the bond. Moreover, at the redemption the asset swap buyer is compensated only by the recovery amount of the bond. As a result, the asset swap buyer has a default exposure to the mark-to-market of the interest rate swap together to the underlying bond. For this exposure the buyer is compensated by the above-mentioned asset swap spread.

2.3.2 *Total Rate of Return Swaps*

Total rate of return swaps (TRORS) have to some extent similar features as the asset swaps described in the previous section. As in asset swaps the credit risk related to the underlying bond is transferred from the one counterparty to another. The structure of TRORS is illustrated in the Figure 2.2.

Figure 2.2 Total Rate of Return Swaps



Source: Bowler & Tierney (1999a)

In TRORS the total rate of return payer acquires credit protection for a reference asset, usually a bond. In total rate of return swap the TROR payer remains the owner of the credit risk instrument but hedges the risk by creating a short position in the asset by paying the total rate of return in return for a floating rate equal to Libor plus spread. The total rate of return, which the payer makes to TROR receiver, consists of the coupon of the reference asset plus any change in value of the asset. For example, if the asset appreciates the TROR payer is required to compensate the raise in value to the TROR receiver, whereas any depreciation in the asset price is compensated by the protection seller. The payments may occur at certain intervals or only at the maturity of the contract.

The TROR payer need not to have an underlying position in the reference asset, which makes TRORS a flexible tool to short or long an asset that is not owned by the counterparties. As Tavakoli (1998) further states, it is not pure credit protection but a funding cost arbitrage that the TRORS are mainly used for. The funding cost arbitrage is illustrated in the Figure 2.2. The protection buyer is able to obtain financing at the rate of Libor – spread in order to fund the position in credit risk reference asset and thereafter acquire credit protection using total rate of return swaps. In return for the total rate of return the protection buyer gets a compensation equal to Libor + spread from the protection seller. As a consequence, the credit risk associated with the reference asset is mostly eliminated and the protection buyer is able to earn a return equal to spread between the funding cost and floating payment equal to Libor + spread.

2.3.3 Credit Derivative Options

Credit spread options can generally be divided into two categories, to credit spread options and bond options. A credit spread option is an option contract in which the decision to exercise is based on the credit spread of the reference asset relative to the strike spread of the spread option. The spread determination may either be based on the changes in a credit spread relative to risk-free benchmark (the absolute credit spread) or changes in the relative spread of two credit risk products. A call on the spread (put on the bond price) expresses a negative view on the credit and is exercisable on the deterioration of the reference bond. A long position on the put spread option (call on the bond price) indicates positive credit view, i.e. the spread is expected to narrow.

As with the standard options, credit spread option counterparties must agree on the contract terms and specifications, i.e. whether the option is a call or put, the expiry date of the option, the strike spread and whether the option is of European or American type. The option premium is usually paid upfront, although it can also be converted into a series of regular payments in return for the option seller's agreement of redeeming the option once it is exercised.

Bond options, on the other hand, are instruments, which give the investor a right to buy or sell an underlying bond with a certain strike price. Underlying bonds are usually liquid credits, such as bonds of the largest corporations or treasuries. A bond put option gives the holder a right to sell the underlying asset at a predetermined price for example in the case when the bond price is deteriorated due to an increase in credit risk. For this default protection, the option buyer pays a premium, which is either an upfront fee or a periodic payment. Call option instead gives the holder of the option a right to buy the bond with a predetermined price, i.e. the bond call option can be used to take advantage of the positive credit view. Bond options are typically physically settled. For example, when a call option is exercised, the options writer delivers the reference asset to the option holder.

2.3.4 Other Credit Derivatives

In addition to above described credit derivative instruments, there are a number of less common instruments, which can be tailored for management of credit and spread risk. Among the most important are the credit-linked notes (CLN), which in basic form are structured medium-term notes with embedded default swaps. In CLN the investor basically has a long position in a reference asset and short on the credit default swap related to some other reference entity, such as some specific corporate loan, sovereign debt instrument or emerging market index. In effect the investor is selling protection on the CDS reference asset and receiving compensation for the credit risk that is involved in the transaction. If no credit event occurs, the investor is entitled to this excess yield throughout the contract maturity. However, in the case of default of reference entity the investor sustains the loss equal to the fall in value of reference entity.

Other interesting credit derivative instruments include for example special repackaging programs. Repackaging program includes placing securities and credit derivatives in a special purpose vehicle (SPV), which then issues a customised product backed by the instruments in SPV to meet the specific credit management needs of the investor. The idea behind the repackaging programs is to offer investor products, which have appealing features but that are otherwise inaccessible or unappealing, in a repackaged form to meet the specific investor's needs. In the simplest case, a repackaging program may consist of repackage of a standard asset swap. If the investor due to regulatory, investment guideline or to some other reason is not able to enter into interest rate swap contract included in the asset swap, the transaction can be done using SPVs. Instead of receiving floating rate in the interest rate swap, the SPV may issue a floating-rate note that pays coupon equal to that of swaps floating leg.

2.4 Economies of Credit Derivatives

The following section discusses the factors that enable counterparties to benefit from the credit derivative instruments. The discussion in the section is related to general advantages of the credit derivatives, whereas distinctive CDS related features are discussed later in the chapter. The section is based on J.P Morgan's (1999) credit derivatives guide, in which three distinct arguments for the economies of the credit derivatives are offered.

First, in the credit derivatives contract the reference entity, whose credit risk is being transferred need not to be aware or counterparty of a credit derivative contract. This enables the corporations and banks to transfer the credit risk of the reference entity without interfering with a specific customer relationship. Using, for example, secondary bond markets for the credit risk management the counterparty has to be notified for the ownership transfer of the underlying security, which may in some cases be harmful for the customer relations or in some cases impossible due to contractual reasons.

Further, as the credit derivative contract does not have to be linked to any specific reference entity or asset, the terms including tenor, seniority and compensation can be customised to meet the needs of a buyer and seller of credit risk rather than counterparty's liquidity and term considerations. Moreover, as credit derivatives transaction increase in volume, they are likely to offer unbiased information for the credit spread forward curves and implied volatilities of the credit risk, hence giving beneficial information for the risks involved in the credit markets.

Second, credit derivatives are the first instruments with which the management of the credit risk can be executed with reasonable liquidity. It is possible to short-sell a bank loan, but the liquidity of the markets has effectively inhibited the effective credit management using indirect methods, such as short selling. In contrast, the same transaction can be executed by acquiring credit protection using credit derivatives, such as credit default swaps. Due to the flexibility of the contract terms, the derivatives can be tailored to meet the terms and conditions preferred by the counterparties. In addition to pure hedging, credit derivatives can also be used in trading purposes to benefit from the different credit views. This trading feature is discussed later in the chapter.

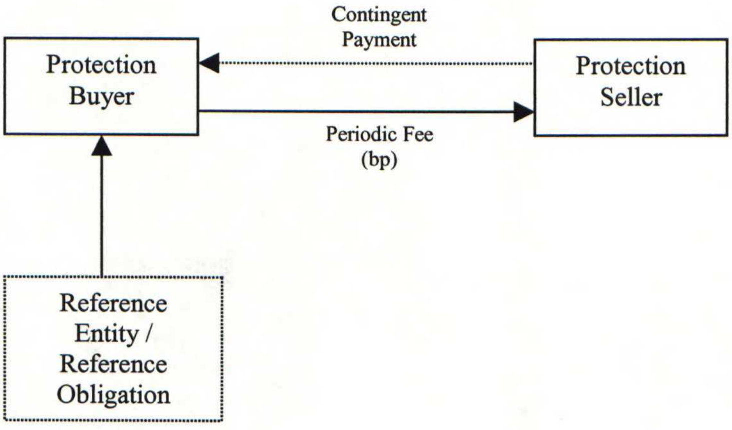
Third, subject to certain regulatory constrains, the credit derivatives are in some cases off-balance-sheet instruments. With off-balance sheet contracts companies and institutions are able to acquire credit exposure without including the underlying items in the balance sheet, hence able to increase the rate of return on capital. However, due to the massive growth in derivatives usage and well-publicised mishaps related to derivatives during the past decade, the accounting bodies have come up with the new reporting standards for the credit derivative instruments. According to the new accounting standards, IAS 39 and FAS 133, introduced in 1998 by the European accounting body International Accounting Standards Committee (IASC) and the U.S. Financial Accounting Standards Board (FASB), most credit derivatives qualified now as a derivative that needs to be fair-valued in the company reporting and therefore included in the balance sheet. Exceptions include for example the cases where the credit default swap is linked to an insurance contract or where the loss is related to a failure to pay or bankruptcy event. (O'Kane, 2001)

2.5 Credit Default Swaps

The current thesis concentrates on the credit default swaps and more precisely on pricing considerations of the CDS instruments. Being the dominant credit derivative instrument, the default swaps have become the basic building block of the credit derivatives market. The credit default swap's simplicity and its ability to offer wide range of applications both to hedgers and investors gives the instrument a competitive edge compared to many other credit derivative products currently on the market.

The credit default swap is a bilateral contract, which allows the investor to buy protection against a risk of default of an underlying reference credit or entity. In a credit default swap contract one counterparty (the protection buyer) pays a periodic fee, typically defined in basis points per annum paid on the notional principal of the contract, in return for a possible contingent payment by the protection seller following a credit event related to the reference entity. The credit default swap can in one sense be regarded as an ordinary interest rate swap, where a fixed leg is equal to the buyer's periodic fee to the protection seller and a floating leg is the contingent payment following the possible credit event. The structure of a basic credit default swap is illustrated in the Figure 2.1. The reference entity represents the underlying credit risk instrument for which the protection buyer acquires credit protection from the protection seller. The upper dashed line depicts the contingent payment following a possible credit event.

Figure 2.1. A Structure of Basic Credit Default Swap



The credit default swap is normally an over-the-counter contract and hence terms and conditions of a contract usually require tailoring between the counterparties. Due to the OTC nature, there are several important features that need to be agreed on and clearly defined in the contract documentation before the actual trade can be executed. Especially during the early years of default swap markets the deregulated nature of contracts and fairly complicated documentation process inhibited the effective use of credit default swaps. However, in July 1999 International Swap and Derivatives Association published a revised credit default swap documentation framework with a purpose to facilitate the CDS trading and to further standardise the contractual issues related to default swap contracts (J.P. Morgan, 1999). As a result, the new framework has streamlined the trade execution and made the further development of the CDS markets possible. The major components of a credit default swap contract are explained below followed by description of different types of CDSs.

As already described above, the credit default swap is a contract that provides insurance against the credit risk of a particular entity, defined as *reference entity*. Default swaps are typically triggered by *credit events* on a broad range of obligations of a reference entity. In the cases, where the term of a CDS contract does not match a cash market credit, a specific *reference obligation* or *asset* is normally used instead to clarify the contract terms. The main purpose of this reference asset is to specify the capital seniority of the debt that is covered by the default swap contract (Bowler and Tierney, 1999a). The reference asset is additionally important in determining the *recovery value*, which is residual value of the underlying asset following default. Recovery amount is needed in order to calculate the payoff amount in a cash settled default swap. The different settlement methods are described in the following section.

A default event related to the reference entity is known as a *credit event*. A credit event triggers the default swap and its definition is therefore one of the most important contractual features in the credit default contract. Credit event definition may include a wide range of triggers related, for example, from the business activities to the general credit quality of the reference entity. In addition to basic credit default swaps, where the credit event is linked to the performance of a single reference entity, there are also default swaps structures in which the contract may be triggered by credit events related to several reference entities and obligations. A credit event may, for example, include the following (O'Kane, 2000):

- Bankruptcy
- Failure to meet payment obligations
- Repudiation
- Material adverse restructuring of debt
- Acceleration of default

It must be noted that, credit event may occur even though the company related to reference entity does not default. This may happen, for example, when a company is obliged to restructure its debt triggering the credit event specified in CDS contract terms, but when a company does not actually go bankrupt.

In addition to above-mentioned features of CDS contracts, the *contingent payment* specifies how the contract is settled after a credit event. A contract may require a certain types of settlement processes, which are explained in more detail in the following section. *Notional principal* indicates the size of a default swap. The most common euro nominated credit default swaps trade with a principal of EUR 10 million per contract.

The Table 2.2 shows the commercial banks to be the main users of the credit default swaps. Both in the protection buyer and protection seller side the banking institutions cover more than 50% of the total number of contracts outstanding on the CDS markets. Being owners of large diversified credit portfolios, credit derivatives offer at the moment perhaps the most effective and liquid way to manage credit risk related to these positions. Additionally, the fact that banks more often acquires than sells protection using CDSs further indicates that the main purpose of the credit default swaps for the banks in general is pure credit risk management and not instead, for example, funding cost arbitrage. However, when observing other institutions can be seen that the emphasis is more on the selling side, suggesting that CDSs are used more often on taking leverage and obtaining possible trading profits.

Table 2.2 A Breakdown of Buyers and Sellers of Credit Default Swaps

Counterparty	Protection buyer (%)	Protection seller (%)
Banks	64	54
Securities firms	18	22
Corporations	7	3
Insurance companies	5	10
Government/export credit agencies	4	1
Mutual funds	1	4
Pension funds	1	2
Hedge funds	0	4

Source: BBA (2002)

Geographically the credit default swaps are spread fairly equally between U.S. and European markets. According to the 2001 credit derivatives survey by Risk Magazine, 41% of the default swaps were linked to U.S. credits, while Europe came little behind with the 38% market share. Further, according to the same report Asia accounts for 13% of the number of reference entities while 8% are left to non-Asian emerging markets.

2.6 Types of Credit Default Swaps

The credit default swaps may, for example, differ by the settlement method following a credit event together with the credit event definitions and types of reference entities. In addition to plain vanilla CDSs, also new innovations of default swaps have been introduced during the past years including for example dynamic CDSs. The types of credit default swaps and related issues are discussed in the following chapter.

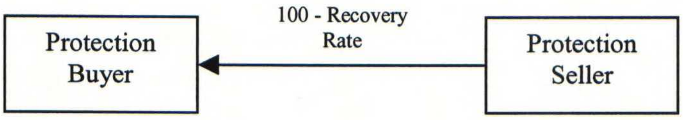
2.6.1 Types of Settlements in the Credit Event

A contingent payment following the credit event can either be a *cash settlement* or a *physical delivery*. The cash settlement is intended to mirror the loss incurred by creditors of a reference entity following the credit event. In a basic credit default swap the cash payment is calculated as the difference in price between par and value of the reference obligation at some predesignated time after the credit event. Typically, the amount will be determined by the calculation agent via a dealer poll of price quotations obtained from dealers of the reference obligations on the valuation date. The valuation is usually conducted within 14 to 30 days from the credit event in order to let the recovery value stabilise. In certain cases, where the pricing of the asset is not possible, there are usually provisions in the contract documentation that allow the price of another asset with similar credit quality and maturity to determine the cash settlement amount. (O'Kane, 2000)

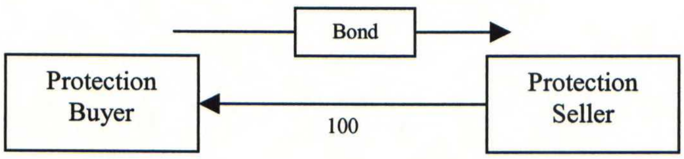
The other settlement method available for the protection buyer is to make a physical delivery. In physical settlement the buyer makes a physical delivery of specified deliverable obligations in return for payment of equal to their face amount. Deliverable obligations may be the reference obligations or some other class of obligations meeting the certain criteria defined in the default swap contract. These specifications may include, for example, the seniority and collateral claim for the protection buyer. The physical settlement option is not always available, since the credit default swaps are often used to hedge exposures to assets that are not readily available for transfer or counterparties have used CDSs to create positions in instruments that are not owned by the participants (J.P. Morgan, 1999). Both the cash settlement and physical settlement process is illustrated in the Figure 2.2.

Figure 2.2 Cash versus Physical Settlement

Cash Settlement



Physical Settlement



Although in general the contingent payment is defined as the par minus recovery value, the contingent amount may instead be a predetermined amount. This type of CDS is known as a *fixed recovery, digital* or *binary default swap.* By fixing the payoff amount in the case of credit event the protection seller is able remove the recovery risk that is present in regular CDS. The leverage feature related to this fixed contingent payment is described in the following chapter.

2.6.2 Other Types of Credit Default Swaps

Contingent credit default swaps is a credit derivative instrument, which in addition to the occurrence of single credit event, requires additional event in order to be triggered. The other trigger is typically a credit event related to another reference entity or a material movement in equity prices, commodity prices or interest rates (J.P Morgan, 1999). While the probability of two credit events occurring at the same time compared to a single one is lower, also the probability of contingent default swaps to be triggered is not as high. This causes the instrument to be cheaper than the regular CDS.

Dynamic credit default swap is a contract, whose notional is linked to the mark-to-market of another reference swap or portfolio of swaps. The notional amount applied in computing the contingent payment in the case of credit event is equal to the mark-to-market value of the reference swap at the time of credit event (J.P Morgan, 1999). Although the MTM of a reference swap and hence the CDS notional is changing, the buyer pays fixed fee as in the regular CDS. As the reference swap counterparty and protection seller are usually separate entities, the protection buyer will incur default losses only if the swap counterparty and protection seller defaults, which makes them attractive instruments to hedge position in instruments with volatile market values. In addition to the above-mentioned direct mark-to–market contingent payment, other types of dynamic CDS structures include for example instruments, which cover any loss beyond a pre-agreed amount or up to some maximum amount.

Basket credit default swaps are structures in which number of different reference entities and reference obligations are specified. With the basket credit default swaps the protection buyer is able to hedge against credit risk of several entities more flexibly compared to buying credit protection for all these reference entities separately. The protection buyer makes the payments to the protection seller in usual way. However, as there are several reference entities, the first credit event related to reference entities triggers a payoff, which is made either in cash or by physical delivery as illustrated above. The contingent payment is typically linked only to the defaulted entity and after the settlement the whole basket CDS is terminated as with plain vanilla credit default swaps.

2.6.3 Benefits for a Default Swap Protection Buyer

In addition to the general advantages of the credit derivatives, Reoch (2002) discusses the benefits for the CDS protection buyer separately. Although the following discussion is related originally to the credit default swaps, most of the features can be associated also to the credit derivatives in general.

As the performance of most of the financial institutions is heavily dependent on the existing client relations the ability to respond to customers' needs is very often crucial for the future success and profitability. Hence, frictionless transactions between the customer and bank are often the cornerstone of effective business. In the cases where a bank's internal or external credit limits and regulations set constraints for the intended transactions, credit derivatives with the same client as a reference entity can in many cases be used to free up credit lines with clients and secure the frictionless trading in the future. Moreover, as credit default swaps are contracts with a third party, a protection buyer is able to hedge credit risk confidentially without affecting the customer relation.

Further, while most credit instruments and consequently the related credit risk can effectively be traded on the financial markets, financial institutions always hold positions in products, which cannot be managed through trading of the actual cash instruments or standard derivatives. Especially in the cases where the rating of the credit is expected to deteriorate the illiquidity of the markets may force a company to sell the credit instrument under its fair value. However, using credit default swaps, which are unfunded products, a company may be able to reduce exposure to illiquid, deteriorating credit and hence prevent the future loss related to the underlying credit.

Third, using default swaps a company is in some cases able to free up risk based or regulatory capital for the better yielding investments. Although due to the immature credit derivative markets the regulations are still evolving, some capital relieves are currently allowed for positions hedged using credit default swaps. With these capital allowances a company is able to manage its credit risk effectively and to allocate the capital in a more efficient manner. In addition to general capital allowances, CDSs also enable the protection buyer to reduce portfolio concentrations by freeing up credit portfolio from risks of certain individual reference entities.

2.6.4 Benefits for a Default Swap Protection seller

As well as for a protection buyer, credit default swaps offer several benefits also to the other counterparty, the protection seller. First of all, when entering in a CDS contract as a seller, the company is entitled to pre-determined periodic income stream, usually called default premium. A protection buyer provides periodic payments for the seller defined in basis points of the contract notional in exchange for the protection. This income received by the protection seller is basically generated without capital involved, offering leverage without any major funding costs and hence increasing rates of return. In similar manner, with CDS contracts a protection seller is able to optimise un-utilised credit lines. Instead of acquiring actual bonds or other credit instruments straight from the cash markets, a company is able to leverage using credit default swaps.

Moreover, the credit default swaps enable the seller to access larger spectrum of issuers and credit markets. In the regular debt capital markets the possibilities of a single mid-sized company to diversify its credit portfolio depends on several factors, such as whether a company is able to participate on a certain debt capital issues and markets it is willing to. However, with CDSs it is possible to diversify credit portfolio to cover wider spectrum of issuers and markets. As default swap counterparties are unconnected to the CDS reference entity or market, a protection seller may in some cases be able to enter the markets that it would otherwise not be able to. In addition to different markets, CDSs also enable a protection seller to access a wider scale of credit instrument maturities to meet the specific duration needs.

Finally, credit default swaps enable a protection seller to avoid political or infrastructural issues associated with accessing certain credit securities and markets. As an example, authorities in countries with less developed financial markets may place restrictions for foreign investors on entering or leaving the markets. This consequently makes the management of credit basically impossible. However, as credit default swaps are contracts with two parties unrelated to any reference entity or market, the credit trading or hedging can be carried out using CDS instead of acquiring the hedge straight from the inaccessible foreign markets.

2.7 Applications of Credit Default Swaps

The following section discusses the investment applications of credit default swaps following the report by O'Kane (2001). The applications of CDSs are divided into three parts, namely hedging, investing and arbitrage.

2.7.1 Hedging with Credit Default Swaps

The initial and basis application for the credit default swaps is the hedging of credit risk. Default swaps are used to hedge concentrations of credit risk in order to decrease exposure to the default risk and to allow for capital relieves. Hedging feature is especially important for commercial banks to manage large credit exposures that exist on their balance sheets. In addition to pure hedging, banks may use default swaps to exploit the relative funding rate advantage between the different institutions. Considering two banks with credit ratings of AA and A- and respective funding rates of Libor minus 20bp and Libor plus 20bp, a following framework can be formed to illustrate the mechanics of the funding advantage.

Supposing that the lower rated bank borrows at its funding rate and takes a long position in the asset paying Libor plus 50bp, it will earn a net spread of 30bp (Libor +50bp from the asset minus Libor +20bp in funding). On the other hand, if AA-rated bank would take a long position in risk-free asset earning Libor, the net spread after funding would be 20bp.

However, suppose that the higher rated bank buys the risky asset and then buys a credit default swap from the lower-rated bank to hedge the aforementioned position, and that this protection costs 40bp. The cash flows from the both above described positions are summarised in Table 2.3.

Table 2.3 Funding Cost Advantage from CDS Protection

The table illustrates the mechanism of funding costs advantage from using credit default swap structure to hedge the related credit risk.

Without Protection

Leg	AA-rated Bank	A-Rated Bank
Asset	Libor	Libor +50bp
Funding	-(Libor -20bp)	-(Libor +20bp)
Net	+20bp	+30bp

With Protection

Leg	AA-rated Bank	A-Rated Bank
Asset	Libor +50bp	0
Default Swap	-40bp	+40bp
Funding	-(Libor -20bp)	0
Net	+30bp	+40bp

The net consequence is that AA-rated bank owns the risky asset and is protected against the possible default. Hence, the position of the AA-rated bank is effectively risk-free and offers a return of 30bp over the risk-free rate indicating a clear advantage in comparison to straight ownership of the risk-free asset. The only default risk of the position is related to the situation where the asset defaults and the protection seller, A-rated bank, is unable to provide the contingent payment. When considering the position of the lower rated bank, can be noted that the bank has basically taken long position in risky asset via CDS and is earning a 40bp spread instead of 30bp when owning the asset directly. Hence, both parties are benefiting from the transaction.

Further benefits of hedging using CDS, as has already been stated, include the feature of credit default swaps to be private transactions between two unrelated counterparties, which enables the effective transfer of credit risk without the customer consent or notification. Banks are accordingly able to hedge credit exposures confidentially without affecting customer relations. In addition, default swaps can be used to hedge exposures where no publicly traded debt exists. The reference entity of a CDS contract does not need to be any specific debt or some other existing instrument, allowing counterparties to hedge credit exposures of companies, which have no publicly traded debt instruments.

2.7.2 Investing with Credit Default Swaps

Credit default swaps do not require any principal or any other capital exchange at the initiation of the contract, which makes CDSs an unfunded way to manage a credit risk. This consequently enables a company to take leverage without involving the capital that would be required in straight cash market equivalents. Moreover, since CDSs are customisable over-the-counter contracts, sellers and buyers are able to tailor the credit exposure to match the preferred requirements in terms of maturity and seniority, which may not be available when using pure cash instruments. Compared to cash instruments, in many cases credit derivatives can also be managed in more efficient manner due to the liquidity of credit derivative markets.

Further, default swaps can be used to take advantage of both positive and negative credit views related to the reference entity. Investors in some cases may not be allowed to sell short an asset in order to hedge against the deterioration of the asset value, but they are able to buy protection using a default swap. This transaction effectively offers the same payoff as shorting the asset but can in many cases be executed with greater liquidity. Similarly, selling a CDS allows investor to benefit from decreasing credit risk of a reference entity. As default swap market premiums tend to closely mirror the corresponding changes in credit quality, spreads are likely to decrease as credit ratings are upgraded.

The fixed recovery default swap introduced in the previous section make it possible for the investors to acquire leverage for their credit position and remove recovery rate uncertainty. Consider a company selling protection with a standard CDS and buying protection with a fixed recovery rate of 50% on the same reference entity, both trades made with the equal premiums. If a default event occurs with a recovery rate of 60%, the investor receives 50% of the contract notional while making a 40% contingent payment generating a profit of 10% of the notional principal. However, even if the matching contract is not made, with a fixed recovery CDS protection seller is able to fix the payment in the case of default hence limiting the possible loss.

2.7.3 Arbitrage with Credit Default Swaps

As the credit derivatives markets are still fairly new and illiquid in terms of contract volumes, some discrepancies between the cash instruments and default swaps may occur leaving a change for arbitrage. Traders can, for example, take the advantage of the price dislocations either by buying the cash instrument and protection with CDS or by shorting the cash and selling protection earning a net positive spread if the default swap market is trading respectively inside or outside to the cash market counterpart.

Moreover, trading with credit trading with the default swaps is in most the cases easier than using the pure cash instruments. Less capital is needed in order to take exposures and over-the-counter nature of default swaps ensures that the maturity and seniority of the contract close to the one preferred. As already discussed, being unfunded products the default swaps offer an attractive way to take leverage for the institutions with higher funding costs.

3 LITERATURE REVIEW

The literature review is divided in to three sections. First, the general literature concentrating on credit risk models is presented. The second section discusses the research concentrating purely on pricing of the credit default swaps. As can be seen, most of the papers related to credit derivatives, and especially to credit default swaps, are published during the last decade indicating the history of academic research to be relatively short. In the final section the previous literature related to bond spread determinants are is presented. As the bond spread play an important role in the empirical part of the study, it is interesting to discuss what factors affect these spreads.

3.1 Credit Risk Models

The credit models can in general be divided into two categories, either in reduced-form or structural models of default. First papers related to structural models, which use contingent claims to determine the price for a given risky bond, were published in the mid 70's when Merton (1974) introduced his classical model. The framework was later extended by e.g. Black and Cox (1976) and Schwartz (1977). On contrast, the history of reduced-form models using abstract firm-value process to define the probability of default is much shorter. As one of the pioneering papers related to reduced-form models is considered the Jarrow and Turnbull (1995) study of pricing credit derivatives. The proceeding studies include, for example, Duffie and Singleton (1999).

In the structural model of default a specific process related to value of a firm is constructed, in which the default occurs when the value reaches a certain threshold. As in the Merton (1974), most commonly the threshold is set equal to function of outstanding debt. In the same model the default is allowed to occur at random stopping times. Merton assumes that the value of the firm follows the geometric Brownian motion and hence has a log normal distribution. In order to value a risky debt a Black-Scholes option pricing framework is used.

Due to the certain problems, such as difficulties of observing the firm value and its volatility, the Merton's (1974) model has experienced several extensions after its introduction. Black and Cox (1976) and Longstaff and Schwartz (1975) allow the default to occur before maturity, while in the Merton (1974) model the default can happen only at the maturity of the bond. Other extensions include for example Geske (1979), who develops a framework which allows for multiple debt issues with different maturities, coupons and seniority. Also a firm's option to issue additional debt is taken into account by Collin-Dufresne and Goldstein (2001), who find that these options increase spreads of previously issued debt.

In contrast to the structural models, the reduced-form models do not require the firm value as input parameter on estimation of the model parameters. In the reduced-form models the credit risk is jointly determined by the occurrence of default and the recovery rate. The stochastic processes used to determine the price of credit risk in the reduced form model are not formally linked to the value of the firm's assets, i.e. they do not explicitly specify or constrain the process by which macroeconomic or firm specific variables affect default probabilities or recovery rates. Default probability is usually represented using random stopping time arrival intensity (hazard rate) or with default probability density, which is closely related to hazard rate approach. In the empirical research on credit derivatives, the recovery rates are usually derived from the past data and usually expected to be constant. For example Jarrow et al. (1997), which is often considered one of the leading frameworks, use the probabilities of credit rating changes and defaults to price the credit-risk bonds.

As the pioneering frameworks on pricing of the credit risk is often considered works of Litterman and Iben (1991) and Jarrow and Turnbull (1995). Their framework is later extended to cover multiple credit ratings by the study of Jarrow et al. (1997) and Duffie and Singleton (1999), whose framework allows the techniques developed for default-free term structures to be applied to defaultable interest rates. Other important contributions in the credit risk pricing models are made by Lando's study (1998), which allows correlation between interest rates and default probabilities and Schönbucher (1998) among others.

In general, the empirical research related to reduced form models has focused on estimating the parameters of one of the following three processes: the hazard process, the spread process or the risky short rate process (Houweling and Vorst, 2002). The hazard rate process which is considered to be the most popular framework among the three, has been studied by several authors during the past few years. The common assumption related to hazard processes that the rate may depend on some state variables reflecting the economical environment or some firm specific information. For example Lando (1998) assumes that the hazard rate can be dependent on number of state variables. On the other hand, Janosi et al. (2000) uses the framework which assumes that the hazard rate is a function of the random elements related to the development of stick price and the short-term interest rate. These works are based on the assumption that hazard rates for corporate bonds vary with the business cycle. For example in the Lando's study (1998) the correlation between the credit and market risk is taken into account using doubly stochastic Poisson process. In the process the probability of default is itself a stochastic process that depends on a wide set of economic variables. Other frameworks related to hazard rate process include Keswani (2000) and Driessen (2001), who apply the Maximum Likehood method with Kalman filtering in order to obtain parameter estimates of Cox, Ingersoll and Ross (1985) processes from time series data.

The second approach concentrating on the spread process refrains from modelling the default and recovery components and concentrates directly on the estimation of the spread process instead. The use of term structure models in pricing of credit-risk securities assumes that the credit risk is fully explained the credit spread curve and its volatility. In general two approaches can be distinguished related to term structure models. First, the general equilibrium theory is base on the framework where interest rate changes are derived from economic agents who maximise the utility. In the equilibrium framework the bond prices and their yields are determined by the evolution of the short-term interest rate. The studies related to this framework include e.g. Vasicek (1977) and Cox et al. (1978). The second approach is based on the no-arbitrage approach, which assumes that no arbitrage is available on the financial markets. The framework takes the yield curve as given and thereafter model the curve dynamics. Examples of studies in this category include Ho and Lee (1986) and Heath et al. (1992).

The studies related to spread process include for example Nielsen and Ronn (1998), who introduce a log-normal spread model using non-linear least squares on cross-sectional data. Tauren (1999) used the Generalised Methods of Methods to estimate the credit spread dynamics of monthly credit spreads on corporate bonds. Maximum Likehood method in spread process have been used by Dülmann and Windfur (2000), who implement a procedure with Kalman filtering to obtain parameter estimates of Vasicek (1977) and CIR models for the instantaneous credit spread. Further, Duffie et al. (2000) use an approximate Maximum Likehood method to estimate a multi-factor model with Vasicek processes.

Finally, the third approach concentrates on considering the sum of the default-free rate and the credit spread to estimate a model for the total risky rate. Duffie and Singleton (1997) use the approach to estimate the swap rate as two-factor CIR process using the Maximum Likehood methodology. In the paper the authors introduce a model to parameterise the behaviour of the joint process for the default-free short rate and the expected loss rate process.

3.2 Credit Default Swap Pricing Models

The academic empirical literature related to the pricing of the credit default swaps is still relatively scarce. Based on above described studies on credit risk pricing, a few studies during the past few years have concentrated on pricing issues of the default swaps.

Hull and White (2000a) provide a methodology for valuing credit default swaps when the payoff is contingent on default by a single reference entity and there is no default swap counterparty default risk. The paper introduces a framework for pricing plain vanilla and binary credit default swaps. The paper also tests the sensitivity of credit default swaps valuation to assumptions about the expected recovery rates. Furthermore, in the same paper Hull and White study whether the approximate no-arbitrage arguments give accurate valuations in comparison to the real market data.

In their paper Hull and White (2000a) first provide a framework with discrete default times and later extend the scope to cover defaults occurring at any time using the probability density approach. The recovery rates in the study are estimated from the historical data. Authors state that it is reasonable to assume that there is no systematic risk in recovery rates and therefore the expected recovery rates observed in the real world can be used as estimates of recovery rates also in the risk-neutral world where the pricing is conducted. Also the impact of expected recovery rate assumptions on pricing of default swaps is studied. Additionally, Hull and White consider the no-arbitrage argument, in which the credit default spread is determined in away that the investor receives exactly the same risk-free cash flows independent of whether he is long in the risk free asset or defaultable bond and credit default swap. Finally, authors apply the model to the single case based on U.S. data in order to check the consistency of the model with the actual market data. According to Hull and White the approach works reasonably well providing a significant improvement over the approach of setting the default swaps spread straight equal to the interpolated bond spread.

Hull and White (2000b) extended their analysis by providing a methodology for valuing credit default swaps that takes account for counterparty default risk and allowing the payoff to be contingent on defaults by multiple reference entities. The model is applied, in addition to single contracts, also to the valuation of basket credit default swaps. In the latter study credit indices are used to define the creditworthiness of CDS counterparties and actual default probability is modelled using the correlated Wiener processes. The results suggest that impact of the counterparty risk on the value of plain vanilla swap is relatively small when correlation between the counterparty and the reference entity is small, but increases as the correlation increases and creditworthiness of the counterparty declines. With the basket spreads, the authors find an increase in CDS spreads as the number of reference entities in the basket increases and decrease as the correlation between them increases.

Houweling and Vorst (2001) compare in their study market prices of credit default swaps with model prices acquired using reduced form model with a constant recovery rate and a polynomial hazard rate function. As Hull and White (2000a), Houweling and Vorst use the no-arbitrage framework in their study. The framework, which uses bond credit spreads as a direct estimate of the default swap premium, is also tested in the paper. Further, concentrating also on the comparison of different risk-free reference rates Houweling and Vorst find that swap and repo curves significantly outperform the government curve in estimation of the default swap spreads. Authors argue that this indicates the fact that financial markets may no longer see Treasury bonds as the default-free benchmark. Also sensitivity of recovery rate assumptions on default spreads is studied with the result that as long as the integrated hazard function is scaled accordingly, the changes in recovery rates do not have major impact on the default premiums.

3.3 Bond Spread Determinants

As the corporate bond spreads are used in the current study as the estimators of the default swap market premiums and the valuation model input parameters, a question arises related to these spreads. If bond spreads can effectively be used in the estimation of credit default swaps, then what determines the actual bond spreads? The determinants of the bond spreads are discussed and empirically tested in number of previous papers. In the literature the most common theoretical factors of the bond spreads are linked to credit and interest rate risks. Two recent papers have concentrated on explaining bond spreads and their changes using U.S. data. First, Collin-Dufresne et al. (2001) examine in their study the determinants of credit spread changes based on U.S data. Authors find that variables that should in theory explain credit spread changes have rather limited explanatory power of 25%. Additionally, authors suggest that the actual credit spread changes are driven by local supply and demand shocks that are independent of both credit and liquidity proxies. As a consequence, the variation in credit spreads of individual bonds seem to be explained more by aggregate than firm specific factors.

Elton et al. (2001) explain in their study the spreads between rates on corporate and government bonds with the U.S. data. As above, the authors show that surprisingly small fraction of the premium in corporate rates over treasuries can be explained with credit risk proxies. As an example, for 10-year A-rated companies expected default probabilities account only for 17,8% of the total spread difference. Instead, authors argue that state and local taxes account for much larger portion of explaining the bond spreads. Although due to the differences in tax code between U.S. and Europe the result may not be generalized as such, they give strong indication of the other factors other than default risk to be important determinants of bond spreads. Finally, in addition to default risk and taxes Elton at al. find that vast majority of unexplained spread is compensation of for systematic risk and closely related to that of the stock markets.

In addition to the theoretical factors bond spreads are argued to be dependent also on market imperfections, such as liquidity. However, due to the difficulties in measurement of non-theoretical factors only few studies during the last years have concentrated on examining these factors. For example Houweling et al. (2002) show that liquidity plays an important role in the pricing of euro bonds. As credit default swaps are regarded as pure credit risk instruments it is interesting to see what effects the above results have on the estimation of the credit default swap premiums using bond spreads. If it assumed that credit default premiums reflect only the credit risk aspect of the reference entity, according to the previous studies the credit default swap quotes should differ from corresponding bond spreads. On the other hand if bond spreads are found to be unbiased estimators of default swap market premiums, one could argue whether the default swap premiums are actually affected also by other factors than pure credit risk.

4 HYPOTHESES

The current chapter presents the hypotheses related to the empirical context of the study. As already discussed above, the purpose of the study is to concentrate on the pricing issues of the credit default swaps using both corporate bond spreads and CDS valuation model as the alternative aspects in valuation. In addition to comparing the two different pricing aspects, the second focus of the study is on the evaluation of the different risk-free interest structures on the credit default swap pricing. Both treasury and swap rates are used as the default-free reference rates in the valuation and consequently the latter part of the hypothesis formulation is related to this feature.

The first aspect of the default swap valuation is related to the corporate bond spreads issued by the CDS reference entity. As in the most major papers related to credit default swaps pricing discussed in the previous chapter of the study, the default swap market premiums are explained by the corresponding corporate bond spreads. In theory the default swap premiums should, subject to certain assumptions, equal the bond spreads. Hull and White (2000a) introduce the approximate no-arbitrage argument to illustrate the relation between these two premiums as follows. Suppose that the investor holds a T-par yield bond issued by a certain reference entity and a credit default swap with the same reference entity. By holding a long position in both of these instruments investor has eliminated most of the credit risk associated with the corporate bond. The situation can be illustrated as follows:

Defaultable Corporate Bond + Default Swap = Default-Free bond

The investor's net annual return from the portfolio is equal to the defaultable bond yield minus the CDS premium that has to be paid from the protection. Hence, in order the arbitrage to be impossible the bond spread over risk-free rate should equal the default swap premium. This relation can be illustrated as follows:

Defaultable Corporate Bond Yield - Risk-Free Rate = Default Swap Premium

However, as for example Houweling and Vorst (2001) state, the relation between the CDS premiums and bond spreads is subject to certain assumptions. First, it is assumed that the defaultable bonds are at par, hence indicating that the yields are equal to their coupon rates. Further, the relation requires the implicit assumption that the bond and default swap pricing models are correctly specified and that the corresponding bonds and default swaps are priced using the same default probabilities. The relation is also discussed by Duffie (1999), who shows that the relation holds exactly only for par floating notes instead of coupon bearing bonds, which typically are the underlying instruments. O'Kane and McAdie (2001) further discuss the factors, which may cause differences between credit default premiums and bond spreads. However, as Houweling and Vorst (2001) state even taking into account the above-mentioned assumptions, the bond spreads and default swap premiums should be comparable.

The second aspect of CDS valuation is related to the estimation of the credit default spreads using Hull and White's (2000a) CDS pricing model that is introduced in the following methodology chapter. Being one of the first valuation models concentrating purely on the pricing of credit default swaps the model implementation offers an interesting insight for its ability to explain the default swap market premiums in the Nordic markets. Moreover, implementation of the valuation model to the default swaps of the smaller and less liquid markets makes the comparison interesting.

In order to sum up the research objectives of the study the three separate aspects can be formulated as follows:

1. Do the corporate bond spreads equal the corresponding credit default swap market premiums or is there any bias between these two spreads?
2. Does the credit default swap valuation model give unbiased estimates of the corresponding CDS market quotes?
3. Which of the risk-free interest rate structures are considered by the markets to be the best reference rates in the pricing of credit default swaps? Both treasury and swap rates are used in the estimation of bond spreads and default swap model premiums.

For the comparison purposes a regression analysis is conducted with the CDS market premiums as the dependent variable together with corporate bond and valuation model spreads as the explanatory variables. The data sets used in the empirical section are described more carefully in the following chapter. The regression equation is defined as follows:

$$y_{it} = \alpha_t + \beta x_{it} + \varepsilon_{it} \tag{5.1}$$

Where

y_{it} : Credit default swap market premium

x_{it}: Corporate bond spread or credit default swap model premium

α_t : Fixed spread effect

β : Bond or model spread coefficient

ε_{it}: Error term

As is illustrated above, in the efficient markets the credit default swap market premiums should equal the corporate bond spreads. Similarly, if the valuation model is correctly specified, the model premiums should be equal to the corresponding CDS market premiums. Additionally, there should be no fixed effect between the CDS quotes and bond together with model spreads, which leads us to the following two hypotheses related the regression equation 5.1.

The first hypothesis concentrating on the fixed effect between the bond spreads and default swap market premiums together with model spreads and CDS premiums can be formed as follows:

Hypothesis 1

H_0: The corporate bond spreads and CDS valuation model premiums are unbiased estimators of the corresponding CDS market premiums, i.e. α_t=0 in the equation 5.1

The second hypothesis related to the regression equation 5.1 is based on the assumption that independent of the absolute spread levels the default swap market spreads should equal the corporate bond and CDS valuation model spreads. Hence, the hypothesis 2 can be stated as follows:

Hypothesis 2

H_0: The corporate bond spreads and CDS valuation model premiums are equal to the corresponding CDS market premiums independent of the absolute spread level, i.e. β=1 in the equation 5.1

As already mentioned, in addition to the two pricing aspects the third emphasis of the study is on the evaluation of alternative risk-free structures in default swap pricing. As the bond and valuation model spread estimation requires risk-free reference rates, two different default-free term structures are used in order to examine the impact of alternative rates for the valuation results. The default-free rates that are used include both treasury and swap rates, which are defined in more detail in the data description chapter. Generally the zero-coupon government bond rates have been considered to be the best estimate for the risk-free interest rates. However, some recent studies, for example Houweling et al. (2001), argue that swap and repo curves make better job in estimation of default premiums indicating that the treasury bonds may no longer be considered by the markets as the reference default-free instrument.

Based on the above discussion the third hypothesis can be expressed as follows:

Hypothesis 3

Instead of treasury rates, swap rates are considered by the markets as the reference risk-free term structure in pricing of credit default swaps.

5 METHODOLOGY

The methodology of the study is based on the Hull and White's (2000a) approach on valuing the credit default swaps. First in the methodology chapter is described the estimation of the model parameters, which include the estimation of default probabilities and the other parameters. The actual credit default swap valuation model is described in Section 5.2. In the final section is illustrated the methodology used in comparison of the default swap market premiums with the corporate bond spreads.

5.1 Estimation of Model Parameters

In order to value the credit default swaps using methodology by Hull and White (2000a), two major model parameters must be estimated. First, as the default swaps are triggered by credit event, usually default, estimation of the default probabilities of the reference entities is one of the cornerstones of the valuation model. Second, as the payoff after credit event is dependent on the recovery rate, estimating the recovery amount is equally important. In addition to recovery amount, also the claim amount, i.e. the amount claimed in the case of default, has an effect on the valuation of the credit default swaps. In the following is described the estimation of the above mentioned parameters together with other considerations of the valuation.

5.1.1 Default Probabilities

Estimation of the default probabilities is based on Hull's (2002) methodology for extracting default probabilities from corporate bond data for discrete maturities. The default probabilities are extracted from bond spreads and estimation hence requires that the default-free zero-coupon bond rates and the corresponding corporate bond yields are extracted from the data set. As will be discussed below, estimation of the model default probabilities is based on risk neutrality assumption. The parameters in the model are defined as follows:

$y(T)$: Zero-coupon yield on a T-year corporate bond
$y^*(T)$: Zero-coupon yield on a T-year risk-free bond
R : Recovery rate
$Q(T)$: Risk-neutral probability that entity will default between time zero and time T

In the case of default, the bondholder receives a proportion of no-default value of the corporate bond defined as R. If no default occurs, the bond is assumed to be redeemed at par at the maturity. Therefore, the bond's no-default value is assumed to be $100e^{-y^*(T)T}$ and the probability of default *Q(T)*, respectively. The value of a credit risk bond can stated as follows:

$$100e^{-y(T)T} = [1 - Q(T)]100e^{-y^*(T)T} + Q(T)100Re^{-y^*(T)T} \tag{5.2}$$

From the above equation 5.1 the cumulative default probability *Q(T)* can be derived:

$$Q(T) = \frac{e^{-y^*(T)T} - e^{-y(T)T}}{(1-R)e^{-y^*(T)T}} \tag{5.3}$$

or equally

$$Q(T) = \frac{1 - e^{-[y(T)- y^*(T)]T}}{(1 - R)} \tag{5.4}$$

As the *Q(T)* represents the cumulative default probability of the reference entity, the discrete marginal default probabilities (p_i) used in the CDS valuation model are needed to be extracted from bond spread data. This is done by calculating the cumulative expected default probabilities using all the corporate bonds available for specific reference entities and for different maturities. The marginal default ratio between the bond maturities at the year-ends is calculated as a difference between the cumulative default probabilities. If the difference in bond maturities of a certain reference entity is more than one year, the marginal default probability is calculated assuming a linear marginal default probability, i.e. the marginal default ratio between bond maturities is divided equally for the years between.

Although the default probabilities in the study are extracted from bond spreads, the default probabilities are also provided by some global rating agencies based on the historical data. In Table 5.1 is shown such information produced by Standard & Poor's in January 2001. The table shows the default experience for ten years time for companies that started with a credit rating illustrated in the leftmost column of the Table 5.1.

Table 5.1 Average cumulative default rates (%)

The table illustrates the historical cumulative default rates for the different S&P credit ratings.

	Term (years)							
Rating	***1***	***2***	***3***	***4***	***5***	***7***	***10***	***15***
AAA	0,00	0,00	0,04	0,07	0,12	0,32	0,67	0,67
AA	0,01	0,04	0,10	0,18	0,29	0,62	0,96	1,39
A	0,04	0,12	0,21	0,36	0,57	1,01	1,86	2,59
BBB	0,24	0,55	0,89	1,55	2,23	3,60	5,20	6,85
BB	1,08	3,48	6,65	9,71	12,57	18,09	23,86	27,09
B	5,94	13,49	20,12	25,36	29,58	36,34	43,41	48,81
CCC	25,26	34,79	42,16	48,18	54,65	58,64	62,58	66,12

Source: Standard & Poor's (2001)

When comparing the historical default probabilities in Table 5.1 and the rates that were extracted from the bond spread data using the above methodology can be noted that the historical default probabilities are significantly smaller than the corresponding default rates estimated from the bond yields. The causes of difference are discussed for example by Hull (2002) based on the former study of Altman (1989). As Hull states, one reason for the difference between the implicit and actual default rates may be that investors require higher expected returns on corporate bonds to compensate for their relatively low liquidity. Another reason may be that the bond traders are allowing in their pricing for the possibility of negative scenarios, in which the default probabilities exceed the rates observed during the time period covered by the historical data. Both of these reasons lead to higher spreads, which consequently imply higher default probabilities.

However, the most important theoretical factor for the default rate differences lies in the risk-neutrality of the rates. It turns out, that the default rates calculated from the bond spreads are the estimates in a risk-neutral world, whereas the historical rates are naturally default probability estimates of the real world. As Hull (2002) states, this explanation is consistent with the pattern of Altman's (1989) results. Moreover, as the valuation of credit default swaps described later in the chapter is done in the risk neutral world, the use of risk neutral default rates is consistent with the valuation framework.

Additionally, although the historical rates would be unbiased estimators of actual default probabilities, they do not reflect the company specific characteristics, which play an important role in estimation of the implied default probabilities. For example in the case, where a company unexpectedly faces financial difficulties, the credit rating is not necessarily adjusted to reflect the changed situation leading to biased estimates when using historical rates.

5.1.2 Recovery Rates and Claim Amounts

The recovery amount is defined as the proportion of the claimed amount in the event of default, i.e. the cash received by protection buyer for the compensation of decrease in the value of the underlying credit risk instrument. In practise the recovery amounts are dependent of several unrelated factors, such as the seniority of the bond and type of business, which make the estimation of the individual recovery amounts in pricing environment difficult. However, as Hull and White (2000a) conclude, it is reasonable to assume that once there is no systematic risk in recovery rates, the recovery rates observed in the real world can be used as unbiased estimators of the recovery rates in the risk-neutral world. Historical recovery rates by seniority of the bonds are summarised in Table 5.2, which includes Moody's estimates from the year 2002 both for European and U.S markets. As can be seen from the table, the average recovery rates have been somewhat lower for the European defaulted bonds than the U.S. equivalents. Noteworthy in the European data is also that the recovery amount among the subordinated bonds is higher than in the higher seniority class.

Table 5.2 Expected Recovery Rates on Corporate Bonds
The table shows the recovery amounts as a percent of par value. Data is from the years 1985-2001.

Class	Average recovery (%)	
	Europe	U.S.
Senior Secured	71,8	66,8
Senior Unsecured	55,0	56,9
Senior Subordinated	20,8	50,1
Subordinated	24,0	32,9
Junior Subordinated	13,0	31,3

Source: Moody's Investor Service (2002)

Being basically the only variable in valuation context of credit default swaps that cannot be directly derived from the market data, one could expect the recovery amounts to have a biasing effect on the results. However, As Hull (2002) states the pricing of a plain vanilla credit default swaps depends one the recovery rate to only a small extend. This is due to the dual effect of the rates used. First, the recovery rate affects the estimates of risk-neutral default probabilities as can be seen from equations 5.3 and 5.4. Second, the recovery amount affects the payoff amount that will be made in the event of default as will be seen in the CDS valuation section. These two effects largely offset each other, decreasing the impact of recovery rate used.

According to the theory, at time t_i the risk-neutral default probabilities should be same for all bonds issued by the same reference entity. Even though in practise recovery rates vary according to the seniority of the different bonds, following Hull and White (2000a) we assume that all the bonds of the certain issuer have the same seniority and that in the event of default the expected recovery rate is constant and independent of time. The consistency of this assumption is tested in the empirical section by using different assumptions for the recovery rates.

The third parameter in the model to be estimated is the contingent amount payable in the case of credit event. As Hull and White (2000a) state, two different claim amounts can be used as the estimates of contingent payment when the valuation is made using deterministic interest rate and constant recovery rates assumptions. The first assumption is to use the claim amount equal to the no-default value of the bond at the time of the default. The other option defines the claim amount as the no-default value plus the accrued interest at the time of default. Hull and White argues that as long as the default events, risk-free interest rates and recovery rates are mutually independent either of these two claim amount assumptions are valid providing that the recovery rate is equal to its expected value in risk-neutral world.

5.2 The Valuation of Credit Default Swaps

The following framework for valuing plain vanilla default swaps follows Hull and White's (2000a) approach and is consistent with the above described estimates of default probabilities. As with the estimation of the default probabilities, default events, interest rates and recovery rates are assumed to be mutually independent. The parameters of the model are defined as follows:

T : Life of credit default swap in years

p_i : Probability of default at time t_i

R : Expected recovery rate on the reference obligation in a risk-neutral world (independent of the time of the default)

$u(t)$: Present value of payments at the rate of one unit of currency per year on payment dates between time zero and time t

$e(t)$: Present value of a payment at time t equal to $t - t^*$ units of currency, where t^* is the payment date immediately preceding time t (t measured in years)

$v(t)$: Present value of one unit of currency received at time t

w : Payments per year made by credit default swap buyer per unit of currency

s : Value of w that causes the credit swap to have value of zero (credit default spread)

π : The risk-neutral probability of no credit event during the life of the credit default swap contract

$A(t)$: Accrued interest on the reference obligation at time t as a percent face value

The probability that there is no credit event during maturity of the contract can be calculated straight from the marginal default probability p_i:

$$\pi = 1 - \sum_{i=1}^{n} p_i \tag{5.5}$$

The protection buyer provides payments agreed in the credit default contract either until the maturity or the occurrence of credit event, whichever is sooner. The present value of expected payments made by the protection buyer equals:

$$w \sum_{i=1}^{n} \left[u(t_i) + e(t_i) \right] p_i + w \pi u(T) \tag{5.6}$$

If the credit event occurs during the lifetime of the contract the protection seller is obliged to pay the counterparty the contingent amount specified in the contract terms. If the credit event occurs at time t, the expected percentage value of the reference obligation, defined as a percentage of its face value, is consequently:

$$1 - \left[1 + A(t_i) \right] R = 1 - R - A(t_i) R \tag{5.7}$$

The present value of the expected payments made by the protection seller is hence the present value of contingent payment weighted with the expected default probabilities, defined as follows:

$$\sum_{i=1}^{n} [1 - R - A(t_i)R] p_i v(t_i) \tag{5.8}$$

The value of a credit default swap contract equals the present value of payments made by the seller minus present value of expected payments made by the protection buyer:

$$\sum_{i=1}^{n} [1 - R - A(t_i)R] p_i v(t_i) - w \sum_{i=1}^{n} [u(t_i) + e(t_i)] p_i + w \pi u(T) \tag{5.9}$$

The periodic payments made by the protection buyer, i.e. w in the equation (5.9) has to be set on level that makes the expression zero. This credit default spread, s, is defined as:

$$s = \frac{\sum_{i=1}^{n} [1 - R - A(t_i)R] p_i v(t_i)}{\sum_{i=1}^{n} [u(t_i) + e(t_i)] p_i + \pi u(T)} \tag{5.10}$$

The variable s is known as the *credit default swap spread* or *premium*. It is defined as the percentage payment of the contract principal made at predetermined intervals. For a single credit default swap contract this spread should in the efficient markets make the contracts mark to market equal to zero.

5.3 Comparison of Default Swap Premiums and Corporate Bond Spreads

The second valuation aspect of the study is based on comparison of the CDS market premiums with the corporate bond spreads. As already in the previous chapter was illustrated, the no-arbitrage argument states that the credit default premiums should equal the corporate bond spreads over the risk-free interest rates. In order to test the hypothesis, consistent pairs of credit default swap quotes and corporate bond spreads need to be extracted from the data set. For each of the quoted default swap premium, we have to find a corresponding bond quote with the same reference entity and maturity. However, as the bond maturities in general do not equal the reference credit default swap maturities, two methods are used in order to extract the bond spread quote with a maturity equal to that of CDS's:

- The bond spread is extracted using two bonds of the corresponding reference entity with the maturities under and above the maturity of credit default swap in question. The bond spread with maturity equal to that of default swap is estimated with linear interpolation from the spreads of the above-mentioned bond quotes.

- In the absence of bonds with maturities under and above CDS maturity, as a reference spread is used the spread of a bond with a closest maturity compared to corresponding default swap maturity.

The regression equation 5.1 is used to compare the credit default premiums with corporate bond and model spreads. The analysis is carried for all the available S&P credit rating groups separately in order to examine whether credit ratings and hence the credit quality has an impact on correlation between default swap premiums, bond spreads and CDS valuation model spreads. Additionally, the corporate bond spreads and model spreads are calculated using the treasury and swap rates in order to study whether there is a difference in their ability to explain credit default swap market premiums. Motivation for using the both rates is given by few recent studies, including Houweling et al. (2001), in which authors indicate that markets may no longer see the treasury bonds as the default-free benchmark. The problem with the treasury rates, in addition to their interest rate risk, is that government papers may be sensitive to liquidity risk, which makes them less appropriate for pricing financial securities. Swaps instead are synthetic instruments that are available in unlimited quantities, allowing greater liquidity and flexibility for investors. Whether swap spreads outperform the treasury spreads in of pricing credit default swaps is examined in the empirical section.

6 DATA DESCRIPTION

The data set used in the empirical section consists of market quotes for defaultable corporate bonds, credit default swaps and default-free interest rates. The dataset is limited to the quotes of the Scandinavian and Finnish companies, which have had outstanding corporate bonds and credit default swaps since the early 2001.

6.1 Credit Default Swap Data

Credit default swap data set consists of bid and asks quotes of credit default swaps of 22 Scandinavian companies. Of the total 22 companies eleven are Swedish, five Finnish, four Norwegian and two Danish. Companies used in the study include most of the biggest corporations operating in the Scandinavian region, with business areas ranging from brewery to telecommunications.

The default swap levels are gathered on a weekly basis from major international investment banks, such as Goldman Sachs and Lehman Brother's, between March 2001 and September 2002. The majority of the quotes are associated with the default swaps of five years maturity while data includes also CDS levels from contracts with a maturities of three, seven and ten years. Totally over 1400 default swap quotes are observed, of which roughly 750 with the maturity of five years together with second largest sample in three year CDSs. Since the five year maturity CDS is the dominant and most liquid instrument in the default swap markets, the study generally concentrates on these instruments using default swaps with maturity of three years mainly for consistency purposes. Virtually all of the quotes are related to contracts with a notional of EUR 10 million, which is the standard contract size in the CDS markets.

6.2 Corporate Bond and Default-free Rates

The corporate bond mid quotes are retrieved from Nordea Analytics, which is an information system of the bank's e-markets portal. As the data source Analytics uses Bloomberg from which the data is retrieved on a daily basis at 16.00 CET. The data consists of daily yield and price quotes of the euro denominated corporate bonds of the above-mentioned Scandinavian default swap reference entity companies. Totally 37 corporate bonds are included in the study, indicating the number of bonds to equal roughly two per company. All bonds are euro denominated, carry various coupons and have maturities roughly between 0,5 and 10 years.

The corporate bond spread figures for the credit default swap reference entities are equally taken from Nordea Analytics. The default-free interest rate structures that are used include both euroregion treasury rates as well as euro swap rates. The zero-coupon government curve is estimated on a daily basis from liquid European government bonds. The bonds include government papers from Germany, France, Denmark and Netherlands with maturities between three months to thirty years and various different coupons. The zero-coupon curves for the government rates are calculated using the NelsonSiegel (1987) method.

The swap curve is estimated using euro denominated interest rate swap contracts with the maturities between one to thirty years. For the maturities less than one year the swap rates are estimated using euro deposit rates and interest rate futures. The zero-coupon curve is extracted using the standard bootstrapping.

6.3 Descriptive Statistics

The section illustrates the descriptive statistics related to the credit default swaps and the corporate bond spreads. The results are reported separately for the default swap premiums and bond spreads together with the brief analysis of the observed spread statistics.

6.3.1 Credit Default Swap Statistics

The descriptive statistics for the credit default swap premium data set are summarised in Table 6.1. The figures reported in the table are related to CDSs with a maturity of five years. The descriptive statistics in the Table 6.1 are reported separately for the mid, bid and ask quotes. The corresponding statistics for the mid quotes of the CDS with the maturity of three years can be found from Table A1 in the Appendix 1.

Table 6.1 Descriptive Statistics of Credit Default Swap Premiums

The following tables include the descriptive statistics of the credit defaults swaps with a five years maturity. The statistics are reported separately for mid, bid and ask quotes and different S&P credit ratings. All the figures are reported in basis points.

Mid Quotes

Rating (S&P)	Average	Median	St. dev	Min	Max	No of obs
BBB-	677	170	629	80	1700	19
BBB	266	178	246	70	1500	175
BBB+	109	70	103	25	570	318
A-	68	72	15	45	97	114
A	31	29	9	18	55	46
A+	68	68	9	58	88	11
AA-	74	50	63	30	278	28
AA	70	68	11	45	90	42

Bid Quotes

Rating (S&P)	Average	Median	St. dev	Min	Max	No of obs
BBB-	632	150	588	60	1640	19
BBB	249	165	233	63	1450	175
BBB+	105	64	105	11	550	318
A-	62	65	16	35	90	114
A	24	23	8	12	45	46
A+	61	40	7	53	75	11
AA-	64	45	54	26	225	28
AA	61	55	11	35	80	42

Ask Quotes

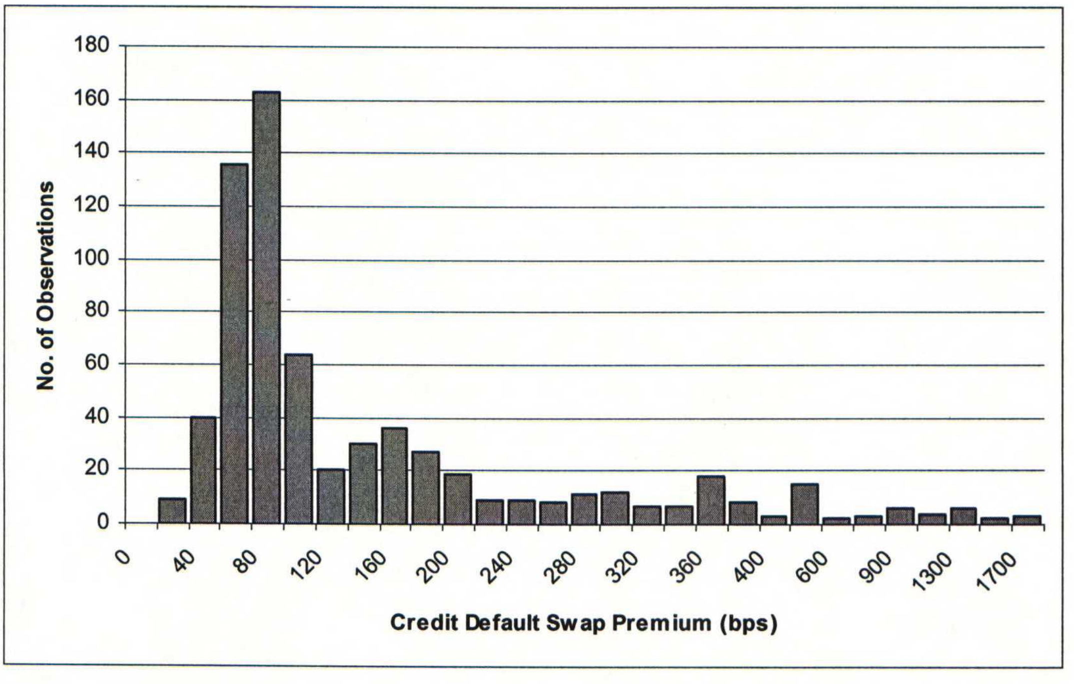
Rating (S&P)	Average	Median	St. dev	Min	Max	No of obs
BBB-	946	1150	645	115	1780	19
BBB	282	190	264	76	1550	175
BBB+	117	75	108	43	590	318
A-	75	77	15	50	104	114
A	36	35	10	20	65	46
A+	75	120	11	63	100	11
AA-	88	56	76	42	330	28
AA	77	79	15	40	100	42

As is expected and can be observed from the mid average quotes, the credit default swap spreads increase when the credit ratings are lower. The effect is eminent especially in the three of the lowest rating groups where the spreads on average more than double each time the rating is downgraded. The pattern, however, inside the four of the highest ratings (from A to AA) is not so clear. With the exception of rating A's 31 bps, the average mid spread quotes in these ratings stay around 60 bps and do not decrease as would be expected. The major reasons for these slightly unexpected results in higher rated groups most likely include the relatively small sample size. While the rating groups from BBB to A- have in total nearly 700 observations and several reference entities, the highest three rating groups include relatively small amount of observations and only one to two reference entities. Consequently, the credit default spreads in four of the highest credit rating groups are likely to be influenced by company specific characteristics and do not therefore reflect the average market default swap premiums related to these ratings. Additionally, as the companies with credit ratings between A to AA generally have strong capital base together with a low expected default probabilities, the corresponding default swap spreads might also be affected by other factors other than credit risk, such as liquidity or some other company specific factors.

In addition to the Table 6.1 the observed credit default swap market premiums are illustrated in the Figure 6.1, which contains the total CDS mid spread quotes divided into different spread level groups. As can be seen from the figure, most of the market premiums remain at the level under 200 basis points indicating the reference entities to be investment grade companies. However, the data set includes also an amount of observations where the CDS premiums indicate the reference entities to be financially distressed and hence contain fairly large amount of credit risk.

Figure 6.1 Histogram of the Credit Default Swap Market Premiums

The histogram illustrates the distribution of mid credit default swap market premiums of the CDSs with the maturity of five years.



When observing the average bid-ask spreads of CDS quotes in Table 6.1 it can be seen that with the exception of the lowest BBB- credit rating, bid-ask spreads remain at the relatively stable 20 bps level. Because the bid-ask spread is often regarded as the best indicator of the liquidity of the credit default swaps, the liquidity considerations are based on the observed spreads. The observed spread figures suggest that the liquidity of the instruments remain at the relatively reasonable level in comparison with the default swap spreads associated with larger and more liquid U.S. and European reference entities. For example Houweling et al. (2001), who examined bid-ask spreads of default swaps using almost 50 000 quotes and 837 reference entities from U.S and European markets found the average spread of the default swaps with BBB-rated companies as reference entity to equal roughly 13 basis points. However, in Houweling and Vorst's study the bid-ask spread of CDSs with BB-rated reference entities was as high as 84 bps indicating the default swap bid-ask spreads to be relatively volatile even in the more liquid markets. Hence, when comparing the observed bid-ask spreads with the statistics of the previous studies, the figures suggest the liquidity of the CDSs used in the study to be at a satisfactory level.

Although the bid-ask spreads in the higher rating groups are relatively small, the spread considerably increases as the rating downgrade. The reasons for over 300 bps bid-ask spread of the lowest rating group is likely to be caused by the small number of reference entities together with low liquidity. Consisting of the quotes of only two reference entities, the BBB- credit rating group does not give a comprehensive picture of the average market quotes of a credit spreads of lower-rated corporations. Additionally, the observed absolute average spread level of over 600 bps in rating group BBB- indicates that the reference companies at least to some extent have financial difficulties, which is likely to increase the bid-ask spread. When observing quotes over the observation period can be seen that the bid-ask levels stay at the relatively stable level throughout the 1,5 year period. However, in the cases where there is clear increase in absolute level of default swap premiums, the bid-ask spreads tend also to widen as expected from the results above.

6.3.2 Bond Spread Statistics

In addition to CDS market quotes, bond spreads are needed in order to compare these two spreads and to estimate the CDS valuation model quotes. The Table 6.2 summarises the key figures from the corporate bond spread data. In the first section of the table are reported the statistics associated with the bond spreads over the treasury rates, whereas the latter section summarises the corporate spread data over the swap rates. All figures in the below table are based on mid quotes.

Table 6.2 Corporate Bond Spreads over Treasury and Swap Rates

In the following two tables are summarised the corporate bond spread statistics of the credit default swap reference entities used in the study. Bond maturities vary between 0,5 to 10 years. All figures in the tables are based on mid quotes.

Bond Spreads over Treasury Rates

Rating (S&p)	Average	Median	St. dev	Min	Max	No of obs
BBB-	1221	1191	856	208	2035	37
BBB	303	228	289	90	1276	436
BBB+	144	117	85	74	531	614
A-	114	114	20	51	190	277
A	88	88	8	70	107	46
A+	88	87	15	72	110	11
AA-	122	106	49	79	284	67
AA	107	113	21	55	127	42

Bond Spreads over Swap Rates

Rating (S&p)	Average	Median	St. dev	Min	Max	No of obs
BBB-	1202	1169	859	192	2014	37
BBB	278	202	288	72	1295	436
BBB+	118	90	87	57	453	614
A-	85	84	19	16	170	277
A	57	56	8	43	72	46
A+	65	67	12	51	81	11
AA-	97	82	48	49	256	67
AA	80	85	19	37	109	42

As can be seen from the Table 6.2, the bond spreads over treasury rates are on average 20-30 basis points higher than the corresponding spreads over swap rates. As discussed by Houweling et al. (2001) this difference is caused by several factors. First, being bilateral contracts between two counterparties swaps contain credit risk premium as investors are exposed to a potential default of the contract counterparty. However, this premium is likely to be small as showed by Duffie and Huang (1996). Second, standard default swap's floating leg is indexed on a short-term LIBOR rate, which is a default-risky rate including a small premium compared to treasury rates. Therefore, the swap rates end up being higher than the corresponding treasury rates even though the swap contract is virtually default-free.

From the Table 6.2 can be seen that as with the credit default swaps, also corporate bond spreads tend to decrease as the credit rating increases. However, once again there is some inconsistency at the higher end of the rating spectrum. This inconsistency, as well as the high spread of credit rating BBB-, is likely to be caused by the small amount of reference entities and observed quotes. As there are on average one to two reference entities inside four of the highest credit ratings, the bond spread quotes are affected by company specific characteristics, such as industry, and hence do not necessarily give a very throughout analysis of the average spreads of the credit rating group the company belongs to. Moreover, as discussed in the section 3.3, also liquidity considerations may have some effect on the observed corporate bond spreads.

7 RESULTS

In the current chapter the empirical results based on the valuation framework introduced earlier in the study are reported. The chapter is divided in two major parts. First, the relation between the default swap market premiums and corporate bond spreads is examined. The empirical results are reported separately for both bond spreads over treasury and swap rates. Second, the results based on implementing the above-described CDS valuation model are reported. Accordingly, the model parameters are estimated using treasury and swap interest rates as risk-free reference rates.

7.1 Credit Default Swap Premiums versus Corporate Bond Spreads

The current section examines the framework according to which the credit default swaps can be explained with the corresponding corporate bond spreads. The expected relation is studied using two different corporate bond spreads, first based on treasury and then on swap zero-coupon rates. In the current empirical section all statistics are associated with the five-year default swap data. As mentioned above, five years is a standard contract length in the default swap markets and hence it is likely to give to most consistent and unbiased results. In order to evaluate the effect of the CDS maturity on the results, the regression analysis is conducted also with the default swaps with maturity of three years. The results are reported in the Appendix 1 in Tables A2 and A3.

In order to compare the default swap premiums with bond spreads, a valid pair of quotes has to be extracted from the data set. The bond spreads used as explanatory variables are the spread quotes of the default swap reference entities with the same date of observation as the corresponding CDS market premium. In order to cope with the maturity mismatch between the CDS and the bond two methods were introduced in the methodology chapter. First, using two bonds of the reference entity, the reference spread is linearly interpolated from the bond spreads to match the CDS maturity. Second, if no such bond can be found, as a reference spread is used the spread of a bond with a closest maturity compared to corresponding default swap.

7.1.1 CDS Market Quotes versus Bond Spreads over Treasury Rates

Table 7.1 shows the regression results from the comparison of credit default swap market premiums and corporate bond spreads over treasury rates. The dependent variable in the regression is a credit default swap premium, whereas bond spreads are used as an explanatory variable. Regression analysis is conducted separately for all the available S&P credit ratings together with all the observations combined.

Table 7.1 Default Swap Premiums versus Bond Spreads over Treasury Rates Regression Results

The dependent variable in the regression set is the credit default swap mid quote with a five years maturity. The explanatory variables in the first regression set are the bond spreads over the euro treasury rates of the corresponding reference entity of the credit default swap. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	Intercept	Bond spread	F-ratio	R^2	Sample Size
BBB-	-151,19***	1,15***	1694,76	0,99	19
	(24,96)	(0,03)	(0,00)		
BBB	-154,21***	1,22***	1518,79	0,90	175
	(12,31)	(0,03)	(0,00)		
BBB+	-56,14***	1,05***	3318,81	0,84	224
	(3,65)	(0,02)	(0,00)		
A-	-6,80	0,72***	240,20	0,54	206
	(5,19)	(0,05)	(0,00)		
A	40,08**	-0,11	0,40	0,01	49
	(15,21)	(0,17)	(0,53)		
A+	35,18**	0,38**	6,05	0,40	11
	(13,58)	(0,15)	(0,04)		
AA-	-126,96***	1,78***	125,81	0,83	28
	(18,64)	(0,16)	(0,00)		
AA	36,70***	0,31***	20,27	0,34	42
	(7,52)	(0,07)	(0,00)		
Total	-60,66***	1,04***	10737,47	0,93	779
	(2,75)	(0,01)	(0,00)		

When observing the regression results in Table 7.1, it can be noted that most of the coefficients, both constants and bond spreads, are statistically significant at 1% level, indicating strong explanatory power of the chosen variables. Of the bond spread coefficients, only the one associated with A-rated companies has no statistical significance. Further, when observing the explanatory power of the each regression equation from the R^2 figures it can be seen that the explanatory power is at a satisfactory level. Ranging from 0,01 to 0,99 among the different credit ratings, 93% of the total variation in the credit default market premiums can be explained with the variation of the corresponding bond spreads over treasury rates. The inconsistent results especially in the credit rating group A are discussed in more detail later in the section.

As stated in the hypothesis section, according to the no-arbitrage theory bond spreads should be unbiased estimators of credit default swap premiums. In the regression analysis context this means that the fixed component in the equation should be relatively small, i.e. the intercept coefficient in the Table 7.1 should be close to zero. Further, as the relation between bond spreads and default premiums is expected to be linear and the spread marginal amounts equal, the bond spread coefficient is expected to be close to unity. In order to test the hypothesis introduced in the chapter 5 a standard two-sided t-test is conducted for each of the model coefficients in the Table 7.1 together with all the other regression sets used in the study. The results from the hypothesis testing can be found in the Appendix 2, where the results are reported separately for the bond spreads and model premiums together for treasury and swap rates. It can be noted that despite the high explanatory power of the variables and the fact that estimated coefficients in most of the cases are consistent with the ones expected, surprisingly many of the zero hypothesis are rejected. The main factor causing the rejection of the zero hypotheses is the high explanatory power of the model and consequently low standard deviation of the coefficients. Even though the coefficients are consistent with the expected amounts, only small deviations of coefficient values from the hypothesed ones lead to rejection of the hypotheses due to the small standard deviation of the estimated coefficient. Hence, the hypothesis testing results should not be given too much weight when evaluating the valuation results.

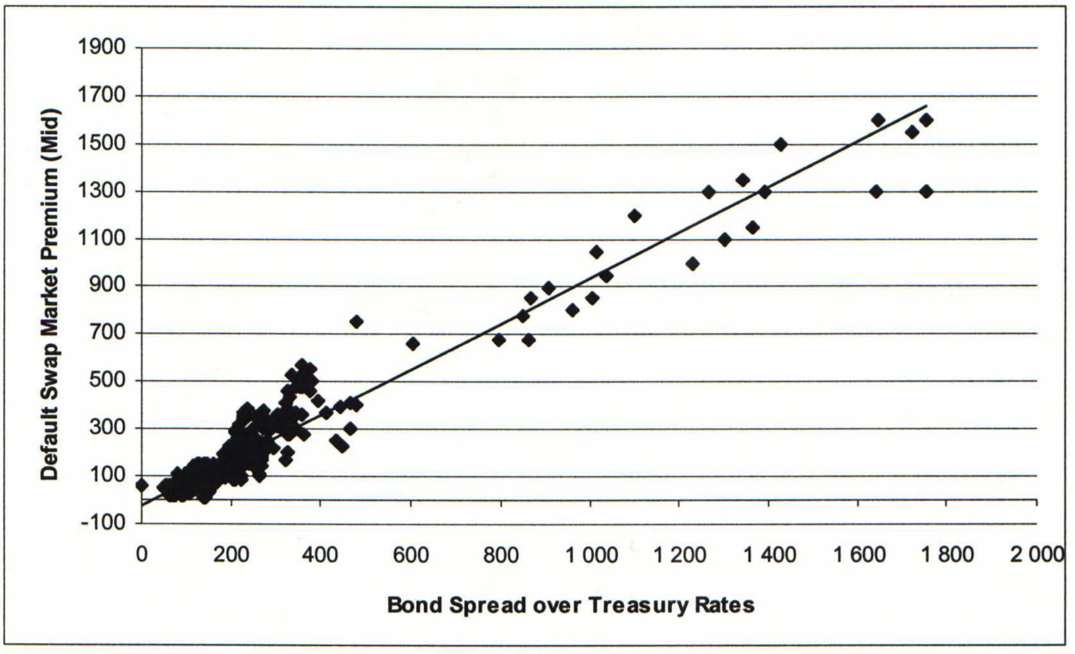
The fixed effect between the CDS market quotes and the bond spreads over treasury rates are estimated using the constant term reported in the second column of the Table 7.1. As the results indicate, all the constant coefficients with the exception of credit rating A- are significant at the 5% level. When observing the constant coefficients in the first regression set can be seen that on average bond spreads somewhat overestimate corresponding credit default swap quotes. Ranging from –154 to 40 basis points, the negative effect in the regression including all the observed quote pairs is –66 basis points indicating that on average the default swap premium is over 0,5% lower than the corresponding bond spread over treasury rates. As is expected, the negative constant effect is largest in the lowest credit ratings, where the absolute level of quotes is also higher. However, as can be seen from the Table 7.1, the pattern in constant coefficients is not consistent throughout all the different credit rating groups. Being significantly negative for the lower credit ratings, the constant term jumps to +40 basis points level for the credit ratings A, A+ and AA indicating the bond spreads over treasury rates to overstate the credit default swap premiums of equally rated companies. These slightly inconsistent results, as discussed below, are likely to be caused by small number of reference entities and sample size in higher credit rating groups together with liquidity considerations.

In addition to the constant term, the regression model consists of the corporate bond spread coefficient, which accounts for the marginal effect of CDS premiums related to bond spreads. The bond spread coefficients from the first regression set can be found in the third column of the Table 7.1. Again, with the exception of the credit rating A, all the spread coefficients are significant at least at the 5% level, indicating a high level of significance. While the expected value of the bond spread coefficient is equal to one, the observed coefficients in the first regression set range from 0,11 to 1,78 whereas the coefficient in the total sample size equals 1,04.

As will be discussed below, the abnormally small (rating A) and large (rating AA-) bond spreads coefficients are likely to be caused by small sample sizes and low spread levels and should therefore not be given too much weight. On the other hand, the most consistent results can be found in the rating groups where the sample sizes are larger and spread on a higher level. With the coefficients of 1,22 and 1,05 of rating groups BBB and BBB+, the figures indicate the marginal spreads to be fairly close to the one expected. When observing the total sample regression figure on the last row of Table 7.1, it can be noted that the coefficient of 1,04 is in fact very close to unity indicating the results to be consistent with the expected hypothesis.

The regression results are additionally illustrated in the scatter diagram in Figure 7.1. The figure follows the same notion as in the regression analysis with the credit default swap quotes on the y-axis and bond spread quotes on the horizontal axis. The figure illustrates the correlation of the two variables to be high, which is consistent with the regression results reported in Table 7.1. As can be seen from the slightly negative intersection point of the trendline and y-axis, the bond spread quotes slightly overestimate the default swap premiums. From the figure can also be observed that most of the bond and CDS spread quotes are at the level below 500 bps, although the data set includes also companies with the spread figures of over 17%.

Figure 7.1 The Relationship between Credit Default Swap Premiums versus Corporate Bond Spreads over Treasury Rates



Although in general the results between the different credit rating groups are fairly consistent with the hypothesis, the unexpected regression coefficients of the A-rated companies raises question for the factors causing the difference. Having a bond spread coefficient of –0,11 and very low explanatory power, the rating group A reported in Table 7.1 conflicts with the results suggested by the hypothesis. The reasons for these unexpected results can in the current case mostly be derived from the underlying data. Two companies are included in the A-rated companies, namely Norsk Hydro and Statoil, both operating in the oil and energy business. The credit default quotes of both companies remain throughout the observation period at low 20-55 basis points spread levels, whereas bond spreads over treasury rates, as can be seen from the constant coefficients, are on average 30-50 basis points higher, although on average still under 1%. Further, while the bond spreads remain relatively stable during the observation period, there is a small negative trend in credit default swap spreads, which leads to the observed negative bond spread coefficient.

It can also be noted that when the spread levels are low and consequently spread changes on average small, the regression analysis is not necessarily able to capture the relation between the CDS and bond spreads. For example, in the above described case both the default swap and bond spreads stay within twenty basis points throughout the observation period indicating the bond spreads to behave as expected related to CDS spreads, i.e. there is no large unexpected change in either of the variables. Consequently, as the spread changes are small, on average less than 10 bps, these changes are likely in many cases to be caused by factors other than credit risk, such as liquidity and changes in supply and demand. Similarly the small changes in CDS premiums and bond spreads often follow slightly different pattern giving above described inconsistent results. Same kind of patterns can be seen also in the credit rating groups A+ and AA, where the spreads are similarly at relatively low level and sample sizes and amount of reference entities small.

All the results and discussion above is based on the comparison of the absolute credit default swap market and corresponding corporate bond spreads. However, the framework reported in Table 7.1 does not take into account the changes in these variables, why an additional regression is conducted also with the spread changes. In the Table 7.2 below the results from the total bond spread data using treasury rates in spread estimation are reported. The dependent variable in the equation is the absolute spread change of the subsequent credit default swap market quotes of a specific reference entity. The explanatory variable is consequently the absolute bond spread change of the corresponding time period and issuer.

Table 7.2 Changes in Default Swap Premiums versus Changes in Bond Spreads over Treasury Rates Regression Results

The dependent variable in the regression set is the absolute change in credit default swap mid quotes of the specific reference entity. The explanatory variable is the absolute bond spread change of the corresponding reference entity. Spreads are estimated using the treasury rates and all default swaps are of five years maturity. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	**Intercept**	**Spread change**	**F-ratio**	**R^2**	**Sample Size**
Total	1,25 (1,08)	0,77*** (0,03)	639,34 (0,00)	0,46	757

From Table 7.2 can be observed that the changes in default swap market quotes can not be explained by the corresponding bond spread changes as effectively as the absolute spread levels. Although the explanatory power of the regression with R^2 figure of 0,46 is still relatively high, compared with the regression results reported in Table 7.1 the significance is however smaller. When observing the coefficients it must be remembered that the constant effect in the regression is eliminated as long as the absolute changes are of similar magnitude. Consequently, the intercept coefficient in the Table 7.2 is only 1,25 basis points indicating that the spread changes between default swaps and corporate bonds on average are at the similar level. On the other hand, the spread change coefficient equals 0,77 indicating that on average 1% change in the bond spread quotes corresponds to 0,77% change in the related default swap market quote. This consequently suggests that the credit default swap market premiums adjust slower to the market information, which is a feasible assumption taking into account the liquidity of the current markets.

7.1.2 CDS Market Quotes versus Bond Spreads over Swap Rates

In addition to comparing default swap market quotes with corporate bond spreads over treasury rates the same regression analysis is conducted with the bond spreads over the swap rates. As for example Houweling et al. (2001) state, the swap curve may in some cases significantly outperform the government curve as the risk-free benchmark. In the current section the results from the second data set based on swap spreads together with the discussion of the results are presented.

The results from the second regression set are summarized in Table 7.3 below using the same framework as in the first regression. The data used in the second regression is equal to that of in Table 7.1 with the exception of using corporate bond spreads over swap rates instead of treasury rates. As the number of reference entities and sample sizes are equal, the results are directly comparable with each other.

The statistical significance of the coefficients is fairly similar to those in the treasury spread regression set reported in Table 7.1. With the exception of constants in credit ratings A- and A, all coefficients are statistically significant at least at the 5% level of significance. Also the R square figures stays at high level ranging from 0,11 to 0,99, while the figure related to the total sample is 0,94 as can be seen on the last row of Table 7.3. Once again the unexpectedly low R square figure of 0,11 in credit rating group A is likely to be caused by the similar factors already discussed related to first regression. The hypothesis testing results can be found from the Appendix 2 in Table A4.

When comparing the constant intercept coefficients in Table 7.3 with those in the regression set using the bond spreads over treasury rates, can be noted that the constant effect in Table 7.3 is on average approximately 20-35 basis points higher than with the spreads over treasury rates. As was already observed in the data description section, the bond spreads over government rates are on average by the same amount higher than the corresponding swap spreads explaining the difference. However, the effect seems not to be consistent between all credit rating groups. For example, within groups A- and A+ the constant is in fact slightly lower than in the previous regression conflicting with the general results. The total sample figure on the last row of the Table 7.3, however, indicates the constant effect to be –32 basis points, which is about 30 basis points higher compared with the figure in the regression set reported in Table 7.1. Consequently, as according to the hypothesis the constant term is assumed to be close to zero, the results indicate that bond spreads over swap rates are more consistent with this hypothesis and hence give less biased results than corresponding bond spreads over treasury rates.

Furthermore, the spread coefficients between the two regression sets seem to be close to one another. Basically only noteworthy differences in coefficients are in the credit rating groups A and A-, where the coefficients in the swap spread regression set are higher and hence closer to unity as expected by the hypothesis. When comparing the explanatory power of the two regression sets can be seen that the corporate bond spreads over swap rates seems to explain slightly more of the variation in default swap premiums than the bond spreads over treasury rates. However, the more important fact is that, as can be seen from the last row of Table 7.3, regression results using the spreads over swap rates are more consistent with the expected amounts suggested by the theories.

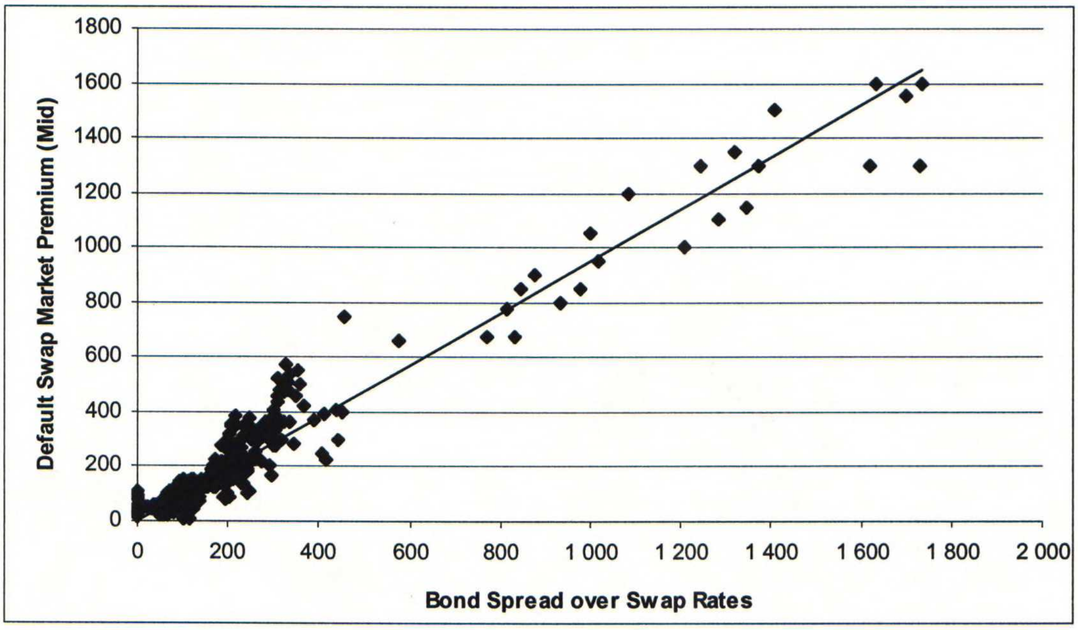
Table 7.3 Default Swap Premiums versus Bond Spreads over Swap Rates Regression Results

The dependent variable in the regression set is the credit default swap mid quote with a five years maturity. The explanatory variables in the second regression set are the bond spreads over the euro swap rates of the corresponding reference entity of the credit default swap. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	**Intercept**	**Bond spread**	**F-ratio**	**R^2**	**Sample size**
BBB-	-128,87***	1,16***	1672,22	0,99	19
	(24,68)	(0,03)	(0,00)		
BBB	-121,77***	1,22***	1645,13	0,90	175
	(11,15)	(0,03)	(0,00)		
BBB+	-25,47***	1,02***	4040,52	0,95	224
	(2,92)	(0,02)	(0,00)		
A-	3,33	0,84***	424,00	0,68	206
	(3,45)	(0,04)	(0,00)		
A	8,27	0,40**	5,89	0,11	49
	(9,27)	(0,16)	(0,02)		
A+	40,29**	0,43*	4,56	0,34	11
	(13,25)	(0,20)	(0,06)		
AA-	-83,26***	1,80***	126,71	0,83	28
	(14,88)	(0,16)	(0,00)		
AA	38,78***	0,39***	28,49	0,42	42
	(6,00)	(0,07)	(0,00)		
Total	-31,75***	1,04***	10501,03	0,94	779
	(2,47)	(0,01)	(0,00)		

As with the CDS spreads over treasury rates, the results are also illustrated in the Figure 7.2, this time using bond spreads quotes over swap rates on the x-axis. As can be seen from Figure 7.2 the trendline intercept is closer to zero, indicating the regression set to give less biased estimated of the credit default swap premiums. The slope coefficient, on the other hand, as can be seen from the last rows of Tables 7.1 and 7.3, is slightly higher when using swap rates, which is illustrated in the form of steeper trendline in Figure 7.2.

Figure 7.2 The Relationship between Credit Default Swap Market Premiums versus Corporate Bond Spreads over Swap Rates



As with the bond spread over treasury rates, the regression on the absolute spread changes is also conducted with the spreads over swap rates. The results are reported in Table 7.4, which shows the findings from the total data sample.

Table 7.4 Changes in Default Swap Premiums versus Changes in Bond Spreads over Swap Rates Regression Results

The dependent variable in the regression set is the absolute change in credit default swap mid quotes of the specific reference entity. The explanatory variable is the absolute bond spread change of the corresponding reference entity. Spreads are estimated using the swap rates and all default swaps are of five years maturity. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	**Intercept**	**Spread change**	**F-ratio**	**R^2**	**Sample Size**
Total	1,05 (0,78)	0,78*** (0,03)	635,80 (0,00)	0,46	757

As with the regression over treasury rates in Table 7.2, the intercept coefficient is close to zero indicating the absolute spread changes to be at the similar level in both of the data sets. The spread change coefficient of 0,78 is slightly closer to one compared to treasury spreads, which suggest that changes in spreads over swap rates are in general closer to the actual CDS market quote changes than corresponding spreads over treasury rates. When observing the significance of the model, can be noted that as with the previous case the bond spreads ability to explain the changes in CDS market quotes is slightly lower than with the absolute levels. However, the R^2 of 0,46 indicate that there is a clear correlation between these two variables.

7.1.3 Arbitrage and other Considerations

As described in the hypothesis section, the first part of the empirical analysis was based on the no-arbitrage assumption. According to the hypothesis the credit default swap premiums should equal the corresponding corporate bond rates over the default-free rates. If this is not the case, the investor is in principle able to acquire a risk-free position with a return excess that of risk-free market rates. Consider for example a case where CDS premium is considerably less than the spread of a bond issued by the reference entity. If the investor is able to acquire a long position in both the credit default swap and the corporate bond, the credit risk related to the corporate bond is basically eliminated. At the same time the investor is able to earn a return excess of risk-free rates due to the described spread difference, hence indicating a possible arbitrage opportunity.

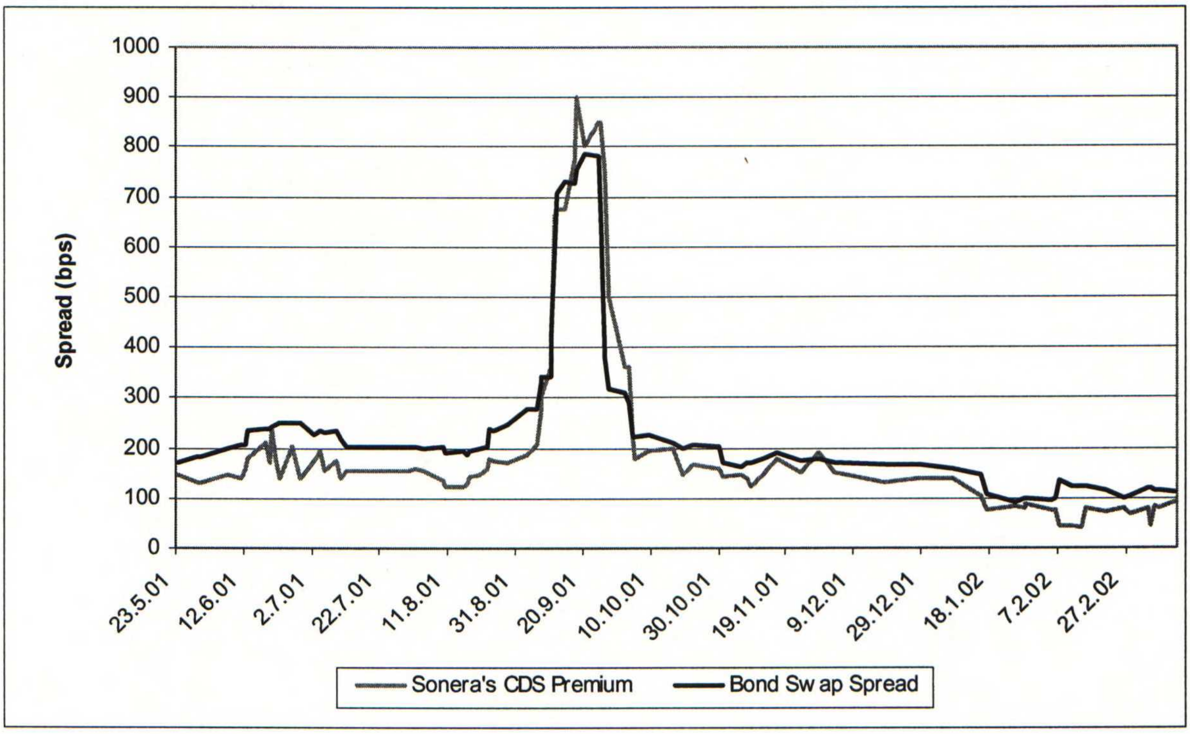
However, in reality the situation is not so straightforward. Although there might be a gap between CDS premiums and bond spreads as can be seen from the regression results above, in practice there are several factors that may prevent the investor from taking the advantage from the above described spread differences. First, as the CDS markets especially in the Nordic region are still relatively young, the ability to find an equal match between outstanding default swaps and corporate bonds is limited. Additionally, even if both instruments exist, the availability of such instruments on the markets is somewhat limited due to the current trading volumes. As the CDSs are OTC-products to meet the specific credit protection needs of the counterparties, the instruments are not in general used in active trading but held by the initial owner until the maturity. Second, the terms and conditions, such as maturity, of a specific default swap contract does not usually match the cash instrument whose credit risk management the CDS is being used. Also the transaction costs and funding rates of protection buyer and seller affect the ability of taking the advantage from the differences in bond and default swap spreads. As a result of these considerations the credit risk cannot be totally eliminated, indicating the possible arbitrage opportunities to be imperfect.

When observing the results from Table 7.1 and Table 7.3 can be noted that on average the corporate bond spreads exceed the corresponding default swap premiums, both using treasury and swap rates as a default-free reference rates. Following the notion above, this suggests that the investor might be able to obtain arbitrage return by acquiring a long position both in credit default swap and underlying credit risk instrument. While such portfolio in principle is protected against credit risk, the investor is able to earn a spread difference between CDS and bonds spread over risk-free rates. However, in reality the arbitrage opportunities are not so evident. As can be seen from the Tables 7.1 and 7.3, the relation between CDS and bond spreads is not consistent between the credit ratios making the exploitation of an arbitrage more difficult. Moreover, as discussed above, such things like maturity mismatch and liquidity considerations make the effective arbitrage difficult.

An interesting feature of arbitrage considerations related to credit default swaps is whether CDS spreads are able to follow large and often unexpected changes in bond spreads usually caused by financial distress. If the CDS premiums do not follow the pattern in bond spreads or there is a clear lag between these two variables, a clear arbitrage opportunity is likely to exist. In order to examine this feature we observed the default swap quotes of Sonera Oyj as reference entity together with corresponding bond spreads over swap rates issued by the same corporation. Both instruments have a maturity close to five years. As can be remembered Sonera suffered during the latter part of year 2001 from a financial distress caused by the excess debt burden from the European UMTS auctions. During that time there was concerns of Sonera's ability to meet its debt obligations, which caused the bond spreads to soar from preceding 200 basis points all the way up to 800 bps level. In the Figure 7.3 are illustrated how the default swap premiums with Sonera as a reference entity together with the bond spreads behaved during the corresponding time period.

Figure 7.3 The Development of CDS premiums with Sonera Oyj as a Reference Entity Compared with the Corresponding Corporate Bond Spreads over Swap Rates

The figure illustrates the development of market premiums of default swap with Sonera Oyj as a reference entity and the spread over the swap rates rates of bond issued by same corporation. Both instruments have maturity close to five years.



As can be seen from the Figure 7.3 the credit default swap premiums follow the Sonera's bond spreads over swap rates quite closely during the financial distress period. Especially during the spread increase the match between two spreads is accurate. The CDS premiums to some extent exceed the bond spread quotes at the top level and stay on a higher level during the period when bond spreads were declining heavily. This suggests that the CDS premiums quickly respond to increased credit risk whereas the adjustments downwards are more careful. During the more stable period can be seen that bond spreads on average exceed the CDS premiums as was suggested by the empirical results. When considering the arbitrage perspective can be concluded that no clear arbitrage opportunity seems to exist either with Sonera's or any other case in the current study context.

In addition to arbitrage considerations, a robustness check of the empirical results is done using the CDS data set containing instruments with the maturity of three years. The framework is the same as regressions reported in Tables 7.1 and 7.3, only this time the default swap and corporate bond maturity equal three years. The results are reported in Appendix 1 in the Tables A2 and A3. Although the sample size is smaller than with the CDS of five years maturity, the results reported on the last rows of the tables are consistent with the hypothesis. In both of the regressions the bond spread coefficient associated with the total sample size is 1.06 whereas the constant effect ranges from -17 to -9 basis points indicating the results to be in line with the hypothesis. Again the bond spreads over swap rates seem to give results closer to those expected by theories.

7.2 Credit Default Swap Premiums versus Valuation Model Prices

The current section concentrates on the second valuation aspect of the study, which uses the Hull and White's (2000) valuation model premiums to estimate the spreads of the corresponding credit default swap market premiums. As with the previous section, both bond spreads over treasury and swap rates are used, this time to extract the default probabilities used in the valuation model. The valuation model is described in more detail in methodology chapter.

As already shown in the Chapter 6, treasury rates and swap rates differ from each other and hence the spread used to extract the default probabilities affect the model output. On average, the treasury rates are slightly lower than the corresponding swap rates. This accordingly results in higher bond spreads and default probability estimates when using treasury rates as the risk-free reference. Therefore in order to examine the effect of the spreads used, both spreads over treasury and swap rates are used as risk-free references.

The default probabilities of the CDS reference entities required in the valuation model as input parameters are estimated using the Hull's (2002) methodology introduced in section 5.1.1. Other assumptions used in the valuation, such as recovery rates and claim amounts, are also discussed in the same chapter. As some of the model parameters cannot be observed directly from the markets, consistency checks are needed related to these parameters, such as recovery rates. The sensitivity of the results for these parameters is discussed later in the chapter.

7.2.1 CDS Market Quotes versus Model CDS Quotes using Treasury Rates

In the first regression set related to model spreads the treasury rates are used in the estimation of the implied default probabilities. The results from the regression set are reported in Table 7.5. The explanatory variable in the regression equation is the credit default swap model premium, whereas the actual market CDS quotes act as the dependent variable. As with the bond spreads, regression analysis is done separately for all the S&P credit rating groups together with the total observations. In addition to observing the explanatory power of the CDS valuation model separately, it is interesting to compare the results with those in the previous section in order to evaluate the consistency of the model prices compared to the bond spreads.

Table 7.5 Credit Default Swap Premiums versus Model Prices Regression Results Using Treasury Rates in Model Parameter Estimation

The dependent variable in the regression set is the credit default swap mid quote with a five years maturity. The explanatory variables in the regression set are the credit default swap model prices. Treasury rates are used as the risk-free rates. The recovery rate used in the estimation of default probabilities and model prices is 30%. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	**Intercept**	**Model spread**	**F-ratio**	**R^2**	**Sample size**
BBB-	-80,68***	0,96***	813,09	0,98	19
	(34,01)	(0,03)	(0,00)		
BBB	-122,51***	1,13***	2036,34	0,92	175
	(10,06)	(0,02)	(0,00)		
BBB+	-63,38***	1,10***	3624,11	0,94	224
	(3,59)	(0,02)	(0,00)		
A-	45,64***	0,29***	108,07	0,36	196
	(2,75)	(0,03)	(0,00)		
A	40,03**	-0,11	0,39	0,01	49
	(15,19)	(0,17)	(0,53)		
A+	35,24**	0,37**	6,06	0,40	11
	(13,55)	(0,15)	(0,04)		
AA-	-116,87***	1,79***	170,57	0,87	28
	(15,30)	(0,14)	(0,00)		
AA	36,75***	0,31***	20,29	0,34	42
	(7,51)	(0,07)	(0,00)		
Total	-37,69***	0,95***	10614,17	0,93	769
	(2,62)	(0,01)	(0,00)		

When observing the regression results in Table 7.5 can be seen that the results in general are statistically very significant. With the exception of model spread coefficient in the credit rating group A, all the coefficients are statistically significant for at least at the 5% level. Compared with the results in Table 7.1, where the default swap market quotes were explained using bond spreads over treasury rates, it can be noted that the significance of the coefficients are in general at the same level. As already discussed in the chapter 7.1.1, the statistically insignificant and partly inconsistent results in higher credit rating groups of A, A+ and AA are most likely to be caused by low absolute spread levels and their small changes together with small sample size and amount of reference entities. Further, ranging from 0,01 to 0,98, the explanatory power of the total sample reported on the last row of Table 7.5 is over 93% indicating the CDS valuation model to be an effective estimator of the default swap markets premiums. The results from the hypothesis testing are reported in the Appendix 2 Table A5. As with the bond spreads, most of the zero hypotheses associated with the model premiums are rejected. This is again mainly due to the high explanatory power of the regressions and low standard deviation of the coefficients. However, as can be seen from the Table 7.5, the results in general are consistent with the hypothesis.

Further, as the statistical significances, also the absolute levels of regression coefficients, compared to those in Table 7.1, seem to be fairly close to each other. In one sense this is not surprising as the corporate bond spreads over treasury rates used in the previous section as the explanatory variables are the most important input parameters in the valuation model. Although there are also other input variables in the model, such as recovery rate, these do not contribute to the model output as much as bond spreads as will be discussed later.

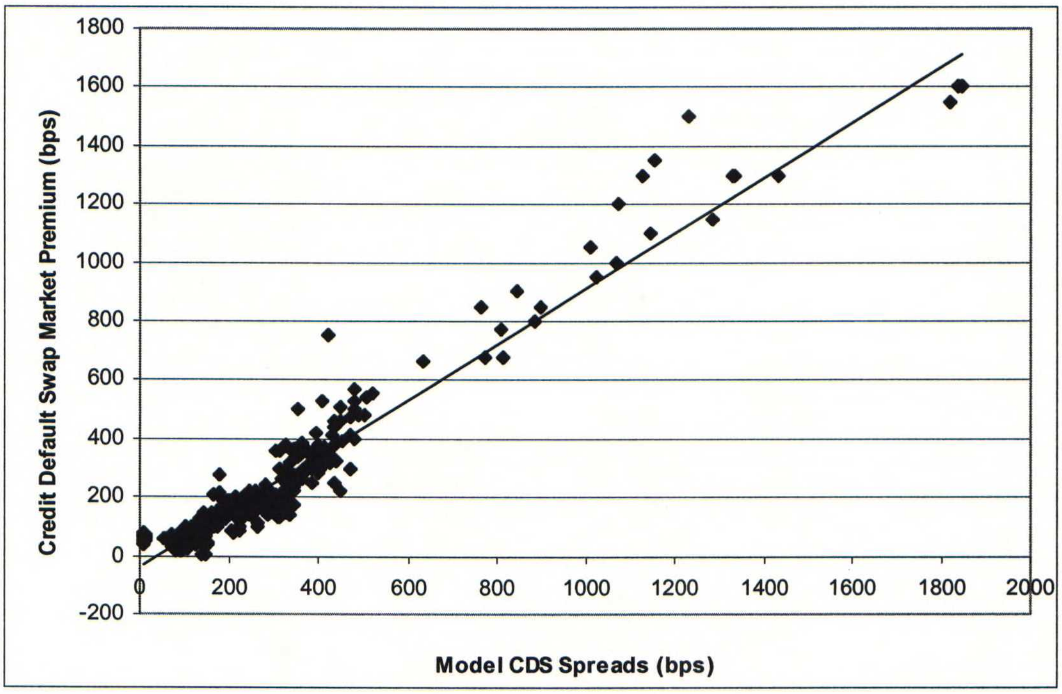
When observing the constant coefficients, can be seen that majority of the intercepts are negative, indicating that the model prices based on default probabilities estimated using treasury spreads somewhat overestimate the actual credit default swap market quotes. The effect ranges from -117 to 54 basis points, while the average overestimation amount equals roughly 38 basis points as is seen on the last row of Table 7.5. As with the first regression set shown in Table 7.1, there is no clear pattern between the credit rating groups, although in credit ratings BBB and BBB+, where the sample size and number of reference entities is largest the constant coefficients are clearly negative. When comparing the total overestimation effect of the model prices with the one in bond spreads over treasury rates can be seen that the constant of 38 bps is roughly 23 points smaller than in the first regression in Table 7.1. As the constant coefficient is expected to be close to zero can be concluded that model prices using treasury rates give less biased estimates of the market CDS premiums than the corresponding bond spreads over treasury rates.

Furthermore, as the constant coefficients, the model spread coefficients, with the exception of credit rating A, are all statistically significant at least at the 5% level. Also the model spread coefficients are fairly close to those in the table 7.1 indicating that the both methods give similar results with respect to the marginal bond or model spread. When observing the model spread coefficient related total sample reported on the last row of Table 7.5 can be noted that coefficient of 0,95 is fairly close to one expected by the hypothesis. In contrast to coefficient of 1,04 in the Table 7.1, the model coefficient suggests that the marginal default swap market quote is roughly 10% smaller related to model prices than to corresponding bond spreads.

As with the previous two regression sets the above results are illustrated also in the Figure 7.4. The CDS markets quotes are placed on the vertical axis and the estimated model prices using treasury rates on the horizontal axis being consistent with the regression notion used. As can be seen from the Figure 7.4, the model prices on average give accurate estimates of the corresponding CDS premiums. Additionally, as can be seen from the trendline intercept, the constant effect in model premium regression set compared to the one where bond spreads were as explanatory variable is smaller indicating the CDS model spreads to give on average less biased results.

Figure 7.4 The Relationship between Credit Default Swap Model Spreads versus Credit Default Swap Market Premiums

The valuation model input parameters are estimated using the treasury rates.



In the Table 7.6 are illustrated the results from the regression where the absolute changes of CDS market quotes are explained by the corresponding changes in valuation model premiums. The treasury rates are used in the model parameter estimation and the results are reported for the total sample including all the S&P credit ratings.

Table 7.6 Changes in Default Swap Premiums versus Changes in Model spreads using Treasury rates in model Parameter Estimation

The dependent variable in the regression set is the absolute change in credit default swap mid quotes of the specific reference entity. The explanatory variable is the absolute model spread change of the corresponding reference entity. Model parameters are estimated using the treasury rates and all default swaps are of five years maturity. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	**Intercept**	**Spread change**	**F-ratio**	**R^2**	**Sample Size**
Total	1,39 (1,07)	0,66*** (0,03)	689,59 (0,00)	0,48	751

As is remembered, comparing the absolute spread changes eliminates the constant coefficient, which can be noted also in the above results. The intercept coefficient of 1,39 basis points suggests that on average the spread changes are very close to each other. However, the spread change coefficient of 0,66 indicates that the model prices on average overestimate the corresponding changes in market CDS quotes. Taking into account the similar results in Tables 7.2 and 7.4, which include the results from the regression using changes is bond spreads, this is not surprising as the bond spreads are the major input parameters in estimation of the default probabilities and consequently the model spreads. The explanatory power of the regression with the R^2 figure of 0,48 is close to the regressions using bond spread changes as the explanatory variable.

7.2.2 CDS Market Quotes versus Model CDS Quotes using Swap Rates

The last section of the empirical part of the study reports the results from the regression set, where default swap model prices estimated using swap rates are used to explain the corresponding credit default swap market quotes. As with all the three previous regression sets, the results are reported separately for different credit ratings together with the total sample size.

Once again, the coefficients in Table 7.7 are statistically highly significant. Basically all the constant and model price coefficients, with the exception of the constant coefficient in credit rating group A, are significant at least at the 5% level, indicating the coefficient to have high explanatory power. Likewise, when observing the explanatory power of the total sample on the last row of Table 7.7, it can be seen that the regression equation is able to explain 92% of the variation between the variables, i.e. the CDS pricing model gives accurate estimates of the default swap market quotes.

Table 7.7 Credit Default Swap Premiums versus Model Prices Regression Results Using Swap Rates in Model Parameter Estimation

The dependent variable in the regression set is the credit default swap mid quote with a five years maturity. The explanatory variables in the regression set are the credit default swap model prices. Swap rates are used as the risk-free rates. The recovery rate used in the estimation of default probabilities and model prices is 30%. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

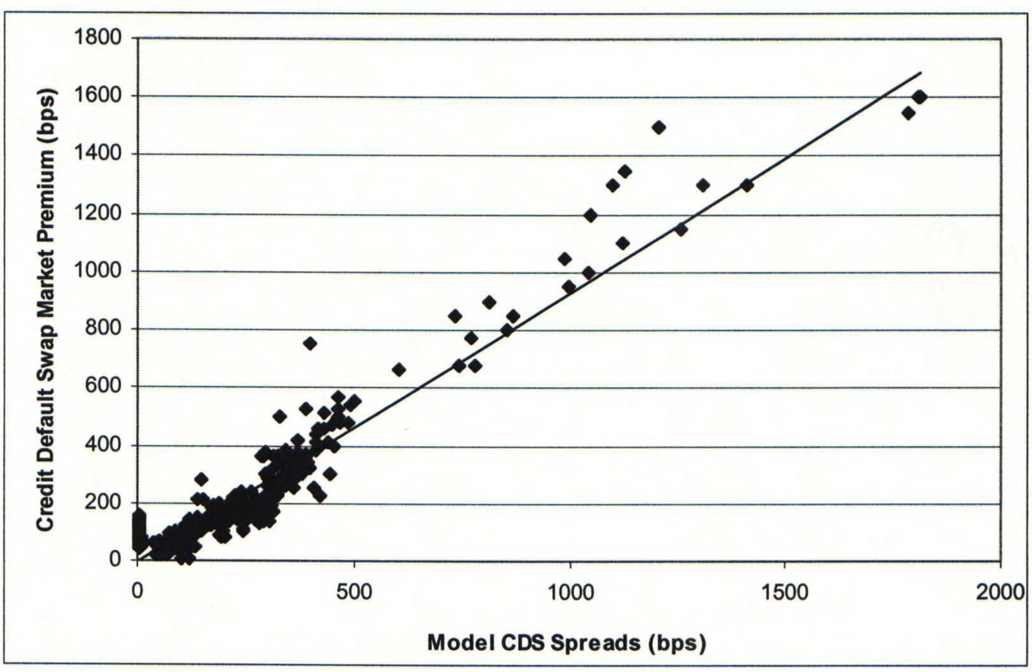
	Coefficients				
Rating (S&P)	**Intercept**	**Model spread**	**F-ratio**	R^2	**Sample size**
BBB-	-62,41*	0,97***	813,43	0,98	19
	(33,48)	(0,03)	(0,00)		
BBB	-92,35***	1,13***	2166,70	0,93	175
	(9,21)	(0,02)	(0,00)		
BBB+	-30,90***	1,07***	4488,95	0,95	224
	(2,84)	(0,02)	(0,00)		
A-	47,77***	0,39***	105,17	0,35	196
	(2,77)	(0,04)	(0,00)		
A	8,29	0,40**	5,89	0,11	49
	(9,26)	(0,16)	(0,02)		
A+	40,32**	0,43*	4,57	0,34	11
	(13,23)	(0,20)	(0,06)		
AA-	-68,75***	1,74***	128,55	0,83	28
	(13,58)	(0,15)	(0,00)		
AA	38,82***	0,39***	28,50	0,42	42
	(5,99)	(0,07)	(0,00)		
Total	-2,17***	0,93***	9255,42	0,92	769
	(2,56)	(0,01)	(0,00)		

When comparing the intercept coefficients in the Table 7.7 with the model results using treasury rates reported in Table 7.5, can be seen that the constants are on average at 30 basis points higher level. While the model prices calculated using treasury rates somewhat overestimated the default swap market quotes, this means that the CDS valuation model premiums estimated using swap rates should give less biased estimates of the these market premiums. Indeed, reported on the last row of Table 7.7, the constant coefficient related to total sample size is only –2 basis points, which is very close to the zero expected by hypothesis. When observing the separate credit rating groups, it can be noted that although there are still deviations in constant coefficients between the credit rating groups, the coefficients on average are closer to zero compared with all other three regression sets. This consequently indicates that the model prices estimated using swap rates as default-free reference rates give most accurate estimates of the actual market quotes what comes to the biasness of the results. Further, as from the model spread coefficients in Table 7.7 can be seen, the coefficients are close to those estimated in the preceding model regression set reported in Table 7.5. Ranging from 0,39 to 1,74, the coefficient with the total sample size is 0,93, being slightly lower than in Table 7.5 but once again fairly close to unity as expected by hypothesis. Again, the hypotheses introduced in the Chapter 4 are tested in Appendix 2.

The correlation between model prices estimated using swap rates and CDS market quotes is illustrated in Figure 7.5 using the same notion as with other three regression sets. As was already seen from the regression results, the constant effect in the regression was found to be very close to zero, which is illustrated in the trendline intercept to be close to the y-axis zero value. The model spread coefficient is slightly less than one.

Figure 7.5 The Relationship between Credit Default Swap Market Premiums versus Credit Default Swap Model Spreads

The valuation model input parameters are estimated using the swap rates.



If we compare the differences between bond spreads and model prices as estimates of the default swap market quotes as a whole, it seems that the bond spreads on average slightly overestimate the CDS market quotes while model prices seem to be less biased estimator. The marginal effect of the bond spreads on the other hand, i.e. the bond spread coefficient, seems to be slightly higher than the corresponding model spread coefficients. The results therefore suggest that when the absolute bond spreads are at the low level, the quotes overestimate the CDS market premiums, whereas at the higher level of bond spreads the effect is smaller. On the other hand, the model spreads, as can be seen from the coefficients in Tables 7.5 and 7.7, give unbiased estimates of the credit default swap market quotes when the spread levels are low, while the model prices on average slightly overestimate the actual market quotes when the CDS premiums are at a higher level.

The last regression on spread changes reported in Table 7.8 uses swap rates in model parameter estimation. As in the Table 7.6 the results are reported for the total sample size hence including all credit ratings.

Table 7.8 Changes in Default Swap Premiums versus Changes in Model spreads using Swap rates in model Parameter Estimation

The dependent variable in the regression set is the absolute change in credit default swap mid quotes of the specific reference entity. The explanatory variable is the absolute model spread change of the corresponding reference entity. Model parameters are estimated using the swap rates and all default swaps are of five years maturity. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	**Intercept**	**Spread change**	**F-ratio**	**R^2**	**Sample Size**
Total	1,10 (1,07)	0,66*** (0,03)	678,55 (0,00)	0,47	751

The results in Table 7.8 are very close to those estimated using the treasury rates instead of swap rates in model parameter estimation. Basically the only difference is in the intercept coefficient, which is 1,10 basis points compared to the figure of 1,39 using the treasury rates hence indicating a slightly better fit. The spread coefficient of 0,66 again suggests 1% change in the model spreads to correspond to the change of 0,66% in the actual market CDS spreads. The explanatory power of the regression is in line with the three other analyses concentrating on explaining the spread changes.

7.2.3 Other Considerations

As discussed already above, the credit default swap valuation model includes several input parameters, which affect the model output. Of these parameters the default probabilities perhaps have the biggest contribution to the results. Luckily, as illustrated in the methodology chapter, the estimates of the default probabilities can be extracted straight from the actual bond spread market data. On the other hand, the recovery amounts, as discussed in Chapter 5 are highly case dependent and hence the accurate estimation of these rates is basically impossible. However, as Hull and White (2000a) state, the historical recovery rates are unbiased estimators of the actual rates and can therefore be used as the estimates in the model. From the Table 5.2 can be seen that in the Euroregion the average recovery rate of subordinated loan have been around 20%, while the corresponding figure in U.S markets is over double the size. The model recovery rate used in the model implementation reported in the Tables 7.5 and 7.7 equals 30%. The same recovery rate is also used by Hull & White (2000a) in their paper related to credit default swap valuation.

As the recovery rates are case-dependent and therefore volatile, a question arises how much the model prices are affected by the changes in recovery rate used in the model parameter estimations. As Hull and White (2000a) state in their paper, the pricing of plain vanilla credit default swaps depend on the recovery rate to only a small extend. This is due to the fact that at the same time it affects the estimates of risk-neutral probabilities and the contingent payoff estimates. These two components largely offset each other leaving the results relatively insensitive to recovery rate assumptions. As a robustness check the model price valuation was conducted in addition to the 30% also using the recovery rate assumption of 50% in order to test the sensitivity of the results for the alternative assumption. The results were found to be very close to those reported in Tables 7.5 and 7.7. In the regression analysis carried out for the total sample size, the difference in the coefficients was insignificant, why the results are not reported separately. This consequently suggests that the small changes in recovery rate, as long as the recovery rates are consistent with the historical estimates, do not have a larger effect on model CDS spreads.

However, as a robustness check the same model regression analysis was additionally made for the model prices assuming a zero recovery in order to examine what effect this has on the obtained model CDS premiums. The results related to this analysis are reported in Appendix 3. As can be seen from the results in Tables A6 and A7 the explanatory power of the model premiums estimated using both treasury and swap rates are at a high level even though the recovery rate assumption of 0% is not consistent with the historical averages. When observing the coefficients related to total sample sizes on the last rows of Tables A6 and A7 can be seen that the constant coefficients compared to those in Tables 7.5 and 7.7 are on average at 10 basis points lower level than in the regressions using 30% recovery. On the other hand, when observing the model price coefficients in Appendix 3 can be seen that the model coefficients are close to 1,50, indicating that the marginal effect related to model prices using zero recovery is not consistent with the one suggested by hypothesis but almost 50% higher. As a comparison, the same coefficients using the 30% recovery can from the Tables 7.5 and 7.7 be seem to equal 0,95 and 0,93, respectively. As a conclusion can be stated that the model prices are insensitive to changes in recovery rates as long as the recovery rates are consistent with the historical data. However, as discussed above and can be seen the from Tables A6 and A7 in Appendix 3, the CDS valuation model gives inconsistent result when the recovery rate is not adjusted to match the historical rates.

8 CONCLUSIONS

The purpose of the study was to concentrate on pricing issues of the credit default swaps with a Scandinavian or Finnish company as a reference entity. Two aspects of credit default swap pricing were concerned. First, the CDS market quotes were explained using the corresponding corporate bond spreads. Secondly, the same default swap market premiums were estimated using the Hull and White's (2000a) valuation model described in the methodology chapter. In addition to the pricing aspects, the third emphasis of the study was on the evaluation of the different risk-free term structures for the pricing of the default swaps. As recent studies (e.g. Houweling et al., 2001) suggest, the market may no longer see the treasury rates as the best risk-free benchmark. In order to study this aspect, both treasury and swap rates were used as a risk-free benchmark.

8.1 Summary of the Empirical Findings

The first part of the valuation was based on the no-arbitrage framework and concentrated on explaining the default swap market quotes using the corresponding corporate bond spreads, both over treasury and swap rates. In order to compare the CDS market premiums and corporate bond spreads, a regression analysis was conducted for all the S&P credit ratings separately together with the total sample size.

The results between the different credit ratings are somewhat mixed, although the total sample indicated the results to be well consistent with the suggested hypothesis. The factors causing the inconsistency especially in the higher credit rating groups were discussed more in more detail in the results chapter. When considering the difference between the bond spreads over both treasury and swap rates, in accordance with the recent studies it seems that the bond spreads over swap rates give less biased estimates of the corresponding default swap market premiums rates than the spreads over treasury rates.

As can from the Tables 7.1 and 7.3 be seen, on average the bond spread quotes slightly overestimate the default swap quotes. The effect with the bond spreads over treasury rates is about 60 basis points, whereas the same figure using the swap spreads is roughly half the size. The marginal effect being close to one is consistent with the hypothesis in both of the regressions. As the bond spread framework was based on the no-arbitrage argument, the observed difference in default swap market quotes and bond spreads raises a question of possible arbitrage opportunities. However, as in the above was discussed, taking into account the liquidity of the current Scandinavian CDS markets and instrument availability together with other considerations, the arbitrage opportunities on a regular basis seems not to be a major issue. The arbitrage considerations were additionally examined using the case Sonera Oyj giving further indications of the relatively good efficiency of the Scandinavian default swap markets.

In addition to the absolute spread levels of the credit default swaps and corresponding corporate bonds, the regression analysis was conducted for the differences of the same quotes. With the slightly lower explanatory power using both the bond spreads, the results suggest that although the absolute bond spreads over treasury and swap rates are fairly unbiased estimators of the CDS market quotes, there seems to be more deviation when the absolute changes are concerned. Moreover, results indicate that on average the default swap market quotes adjust slower to the changes in corresponding bond spreads, which is a feasible result taking into account the liquidity of the current markets.

The second valuation aspect of the study concentrated on explaining the credit default swap market premiums using the Hull and White's (2000a) valuation model. The model input parameters, most importantly the default probabilities, were extracted using bond spreads both over treasury and swap rates. In order to compare the model premiums with the CDS market quotes a similar regression analysis as with the bond spreads was conducted for all the S&P credit ratings together with the total sample.

The results from the model premium regressions are reported in Tables 7.5 and 7.7. As can be seen from the intercept coefficients, the overestimation effect of default swap market premiums using the model premiums instead of bond spreads is slightly lower. In fact, the average constant effect when using the swap rates in model estimation is only about three basis points indicating the results to be very unbiased. In the CDS model premiums estimated using the bond spreads over treasury rates the overestimation effect is larger than with the swap rates, although smaller compared to the corresponding bond spreads. The model price coefficient in both of the regressions is around 0,94, indicating the marginal effect to be lower than with the bond spreads, however still close to one expected by the hypothesis.

The regression for first differences of spread quotes was also made using the CDS valuation model premiums. The results from the regression using total sample size are reported in the Tables 7.6 and 7.8. The results indicate that the changes in the actual CDS market quotes with respect to the model premiums are slightly smaller compared to the changes in bond spreads, hence indicating model premiums to slightly more volatile compared to corresponding bond spreads. The explanatory power of the regressions are, however, equal to those using bond spreads.

The empirical findings of the study suggest that both the corporate bonds spreads and the CDS valuation model premiums can be used as the effective estimators of the credit default swap market premiums. When evaluating the different pricing frameworks can be noted that on average the model premiums are less biased estimators of the corresponding default swap market quotes, whereas the marginal effect in both of the frameworks is equally close to that expected by the hypothesis. What comes to the performance of the risk-free reference rates, the results suggest that the swap rates outperform the treasury rates in valuation of the default swaps. The results hence verify the findings of the previous studies (e.g. Houweling et al., 2001) discussed above.

8.2 Suggestions for Further Research

As the framework of valuing credit default swaps is still relatively new, room for further empirical research and model development is certainly available. The current study suggests that the valuation frameworks implemented in the empirical section can successfully be used in the valuation of the smaller and less liquid Scandinavian and Finnish credit default swap markets. However, as the market evolve, additional studies are needed in order to test the robustness and confirm the results and to account for the new aspects in CDS pricing.

An interesting aspect of the credit default swap spreads are their determinants. As discussed in the section 3.3, the determinants of the bond spreads in many cases include other factors than pure credit or interest rate risk. Other the other hand the credit default swaps are regarded as pure credit risk instruments and hence that the major determinant of the CDS market spreads should be the reference entity's credit risk. However, as in the current study was shown and the previous studies suggest, the corporate bond spreads can be used as effective estimators of the corresponding credit default swap premiums. This consequently raises a question, what actually are the underlying determinants of the default swap premiums. If the credit risk do not play the dominant role in determining the CDS spread as is expected, do the determinants perhaps include the same factors that are included in the bond spreads. This aspect is certainly the one that requires further attention and therefore is an interesting issue for further research.

Finally, a potential future development framework related to the credit default swap valuation model includes the estimation of the input parameters. As more comprehensive data will be available, the alternative assumptions can be used for extracting the model parameters. Following Hull and White (2000a) the default probability estimation can, for example, be extended to cover defaults occurring at any time period using the probability density approach instead of discrete default times. Moreover, the effect of the credit rating dependent recovery rates on the model outputs is another interesting aspect that is potential source for the future research. Although the study shows that recovery rates, as long as they are consistent with historical rates, do not have a large impact on the model premiums, it nevertheless would be interesting to examine whether the lower recovery rates among the lower-rated companies give more consistent estimates of the actual credit default swap market premiums.

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APPENDIX 1.

Table A1. Descriptive Statistics of Credit Default Swap Spreads of Three Years Maturity
The following table include the descriptive statistics of the credit defaults swaps with a three years maturity. The statistics are reported separately different S&P credit ratings. All figures are based on mid quotes.

Rating (S&p)	Average	Median	St. dev	Min	Max	No of obs
BBB-	1168	1375	700	65	1900	12
BBB	379	240	392	100	1700	59
BBB+	145	64	148	30	540	107
A-	60	61	11	32	85	43
AA-	44	43	10	36	60	5

The Tables A2 and A3 summarise the results from the default swap premiums versus bond spread regression results. The credit default swaps used in the regression have a maturity of three years.

Table A2. Default Swap Premiums versus Bond Spreads over Treasury Rates Regression Results

The dependent variable in the regression set is the credit default swap mid quote with a three years maturity. The explanatory variables in the first regression set are the bond spreads over the euro treasury rates of the corresponding reference entity of the credit default swap. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	**Intercept**	**Bond spread**	**F-ratio**	**R^2**	**Sample size**
BBB	-28,34	1,07***	262,47	0,82	59
	(33,24)	(0,07)	(0,00)		
BBB+	-47,23***	1,27***	541,65	0,89	68
	(12,46)	(0,06)	(0,00)		
A-	-19,44***	0,85***	230,11	0,80	59
	(5,65)	(0,06)	(0,00)		
Total	-17,23*	1,06***	2348,30	0,92	195
	(9,75)	(0,02)	(0,00)		

Table A3. Default Swap Premiums versus Bond Spreads over Swap Rates Regression Results

The dependent variable in the regression set is the credit default swap mid quote with a three years maturity. The explanatory variables in the first regression set are the bond spreads over the euro swap rates of the corresponding reference entity of the credit default swap. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	**Intercept**	**Bond spread**	**F-ratio**	**R^2**	**Sample size**
BBB	-0,45	1,06***	269,71	0,83	59
	(31,57)	(0,06)	(0,00)		
BBB+	-12,83	1,36***	566,61	0,90	68
	(10,98)	(0,06)	(0,00)		
A-	-4,02	0,92***	268,48	0,82	59
	(4,32)	(0,06)	(0,00)		
Total	-9,12	1,06***	2416,52	0,93	195
	(9,30)	(0,02)	(0,00)		

APPENDIX 2.

Table A4. Hypothesis Testing for the Credit Default Swap Premiums versus Corporate Bond Spreads

	Treasury spreads		Swap spreads	
Rating (S&P)	**Constant**	**Bond spread**	**Constant**	**Bond spread**
BBB-	*Rejected*	*Rejected*	*Rejected*	*Rejected*
BBB	*Rejected*	*Rejected*	*Rejected*	*Rejected*
BBB+	*Rejected*	Not rejected	*Rejected*	Not rejected
A-	Not rejected	*Rejected*	Not rejected	*Rejected*
A	Not rejected	*Rejected*	Not rejected	*Rejected*
A+	Not rejected	*Rejected*	Not rejected	Not rejected
AA-	*Rejected*	*Rejected*	*Rejected*	*Rejected*
AA	*Rejected*	*Rejected*	*Rejected*	*Rejected*
Total	*Rejected*	*Rejected*	*Rejected*	*Rejected*

Table A5 Hypothesis Testing for the Credit Default Swaps Premiums versus Model Spreads

	Treasury spreads		Swap spreads	
Rating (S&P)	**Constant**	**Bond spread**	**Constant**	**Bond spread**
BBB-	*Rejected*	Not rejected	Not rejected	Not rejected
BBB	*Rejected*	*Rejected*	*Rejected*	*Rejected*
BBB+	*Rejected*	*Rejected*	*Rejected*	*Rejected*
A-	*Rejected*	*Rejected*	*Rejected*	*Rejected*
A	*Rejected*	*Rejected*	Not rejected	*Rejected*
A+	Not rejected	*Rejected*	Not rejected	Not rejected
AA-	*Rejected*	*Rejected*	*Rejected*	*Rejected*
AA	*Rejected*	*Rejected*	*Rejected*	*Rejected*
Total	*Rejected*	*Rejected*	Not rejected	*Rejected*

APPENDIX 3.

Table A6. Credit Default Swap Premiums versus Model Prices Regression Results Using Treasury Rates and Zero Recovery in Model Parameter Estimation

The dependent variable in the regression set is the credit default swap mid quote with a five years maturity. The explanatory variables in the regression set are the credit default swap model prices. Treasury rates are used as the risk-free rates. The recovery rate used in the estimation of default probabilities and model prices is 0%. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Coefficients				
Rating (S&P)	Intercept	Model spread	F-ratio	R^2	Sample size
BBB-	-133,22***	0,65***	1443,41	0,99	19
	(26,66)	(0,04)	(0,00)		
BBB	-151,18***	1.79***	1810,23	0,91	175
	(11,24)	(0,04)	(0,00)		
BBB+	-66,85***	1,62***	3492,07	0,94	224
	(3,71)	(0,03)	(0,00)		
A-	45,69***	0,41***	106,8	0,36	196
	(2,96)	(0,04)	(0,00)		
A	40,11**	-0,16	0,39	0,01	49
	(15,30)	(0,25)	(0,53)		
A+	35,02**	0,54**	6,05	0,40	11
	(13,65)	(0,22)	(0,04)		
AA-	-119,29***	2,61***	170,44	0,87	28
	(15,48)	(0,20)	(0,00)		
AA	36,56***	0,45***	20,25	0,34	42
	(7,56)	(0,10)	(0,00)		
Total	-51,44***	1,50***	9363,32	0,92	769
	(2,88)	(0,02)	(0,00)		

Table A7. Credit Default Swap Premiums versus Model Prices Regression Results Using Swap Rates and Zero Recovery in Model Parameter Estimation

The dependent variable in the regression set is the credit default swap mid quote with a five years maturity. The explanatory variables in the regression set are the credit default swap model prices. Swap rates are used as the risk-free rates. The recovery rate used in the estimation of default probabilities and model prices is 0%. Numbers in the parenthesis of the coefficient columns indicate standard deviation of the variable. The numbers in the parenthesis of the F-ratio column are the p-values of corresponding F-ratios. *** , ** and * indicate significance at the 10%, 5% and 1% level, respectively.

	Coefficients				
Rating (S&P)	**Intercept**	**Model spread**	**F-ratio**	**R^2**	**Sample size**
BBB-	-110,67***	1,66***	1412,28	0,99	19
	(26,39)	(0,04)	(0,00)		
BBB	-117,97***	1,80***	1948,43	0,92	175
	(10,19)	(0,04)	(0,00)		
BBB+	-33,39***	1,58***	4320,11	0,95	224
	(2,92)	(0,02)	(0,00)		
A-	47,52***	0,43***	116,55	0,38	196
	(2,51)	(0,04)	(0,00)		
A	8,18	0,57**	5,90	0,11	49
	(9,30)	(0,23)	(0,02)		
A+	40,19**	0,62*	4,56	0,34	11
	(13,30)	(0,29)	(0,06)		
AA-	-70,19***	2,53***	128,39	0,83	28
	(13,70)	(0,22)	(0,00)		
AA	38,68***	0,56***	28,46	0,42	42
	(6,02)	(0,10)	(0,00)		
Total	-11,58***	1,46***	8027,32	0,91	769
	(2,80)	(0,02)	(0,00)		